# OPHTHALMOLOGICAL ANATOMY

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## WITH SOME ILLUSTRATIVE CASES


BY

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# PREFACE

By those of our profession who are engaged in general surgery an accurate knowledge of anatomy as taught in the dissecting room can rarely be retained, and by some would be regarded as prejudicial to their art. The ophthalmic surgeon, in his more limited field, can plead no such extenuating circumstances. If then it be true, as the author fears it is, that ophthalmic science is to some extent hindered by the want of a clear anatomical picture in the minds of those who devote themselves to it, the fact is the more to be regretted; the existence of a remediable defect in this direction should not be regarded with equanimity by ophthalmologists, than whom, it is conceded, none engaged in our profession are more accurate and scientific in their observations or their methods.

In the above frame of mind the author, recently engaged in anatomical teaching, has ventured to write this small volume. It is hoped that the text is sufficiently lucid to recall and impress upon the mind facts with which it must at one time have been stored. A few diagrams have been included, but if the reader has the opportunity of referring to prepared anatomical and osteological specimens he will find them of much assistance.

The smaller works on ophthalmology are deficient, and in some cases not always accurate, in the anatomy which they teach; in some of the larger volumes most of the information may be given, but the reader cuts much time to waste in collecting it.

The author hopes that these few chapters may be a useful supplement to students' text-books and prove a practical help to the clinical ophthalmologist. Much that might have been written under the title of Ophthalmological Anatomy has not been included: the surgeon would not thank the author for a chapter on such a subject as the structure of the eyeball; the student will find the omissions suitably supplied as he reads his text-book.

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With some of the illustrations in this book the reader may already have made acquaintance. As they are largely diagrammatic no advantage, proportionate to the labour involved, would have been gained by the preparation of new drawings from original anatomical specimens ; where necessary diagrams have been modified.

Beneath each borrowed illustration the source from which it has been taken is recognised in the usual way. The author particularly acknowledges the kindness he received from Messrs. Longmans and Co. (the publishers of " Quain's Anatomy "), Cassell and Co. (Treves' Applied Anatomy, and Bland-Sutton's Tumours), and Young J. Pentland (Cunningham's " Practical Anatomy " and " Text-book of Anatomy ").

# CONTENTS

## PART I.

### Ophthalmological Anatomy.


CHAPTER I. PAGE

The Visual Pathways and Centres ... ... ... ... ... 3

CHAPTER II.

The Centres for Ocular Movements ... ... ... ... ... 22

CHAPTER III.

Cranial Nerves: Their Nuclei, Course and Distribution ... ... 27

CHAPTER IV.

The Cervical Sympathetic. The Lenticular Ganglion ... ... 42

CHAPTER V.

Cutaneous Nerve Areas of Head and Face. Cerebral Topography ... 47

CHAPTER VI.

Ocular Movements and Muscles. Paralytic Squint and Concomitant Strabismus. Tenon's Capsule ... ... ... ... ... 52

CHAPTER VII.

The Eyelids and the Lacrimal Apparatus ... ... ... ... 74

CHAPTER VIII.

The Ophthalmic Blood Vessels and Intra-Cranial Venous Sinuses ... 86

CHAPTER IX.

The Orbit and its Surrounding Air-Cells. Some Points in Development ... ... ... ... ... ... ... ... 95

## PART II.

### Illustrative Cases.

PAGE

Case I. Illustrative of Ocular Symptoms in Tabes Dorsalis ... 109

" II. Bi-temporal Hemianopia from Chiasm aLesion ... 111

" III. and IV. Acute Retro-bulbar Neuritis ... ... ... 115

" V., VI. and VII. Ocular Symptoms in Disseminated Sclerosis 120

" VIII. and IX. Lesions of the Corpora Quadrigemina ... ... 126

" X., XI., XII. and XIII. Bullet Wounds involving Cortical Centres of Vision ... ... ... ... ... 132

" XIV. Homonymous Hemianopia of Central Origin ... ... 142

" XV. Paralysis of Third to Twelfth Cranial Nerves of the Left Side, associated with Paresis of the Left Cervical Sympathetic ... ... ... ... 144

Case XVI. Total Left Ophthalmoplegia accompanied on the same side by Paralysis of the First Division of the Fifth Nerve, Optic Papillitis and Neuro-Paralytic Keratitis ... ... ... ... ... 148

" XVII. Paralysis of Cervical Sympathetic from Pressure of a Goître... ... ... ... ... ... ... 152

" XVIII. Paralysis of Cervical Sympathetic from Involvement of the Rami Communicantes from the Upper Dorsal Region ... ... ... ... ... 153

" XIX. and XX. Paresis of an Extra-Ocular Muscle from Hæmorrhage into its Sheath ... ... ... 156

" XXI. Diffuse Cellulitis of Orbit, Secondary to Empyema of an Ethmoidal Air Sinus ... ... ... ... 158

" XXII. Encysted Mucocele of Orbit: Spontaneous Cure ... 170

" XXIII. Septic Thrombosis of the Cavernous Sinus ... ... 172

Index ... ... ... ... ... ... ... ... ... 182

# PART I.

## *Ophthalmological Anatomy.*

# CHAPTER I.

## The Visual Pathways and Centres.

In considering the coarse anatomy of the sensory paths by which the visual impulses travel, the most convenient plan will be to endeavour to trace the fibres from the eyeball to their ultimate destination in relation to the cortex of the cerebral hemispheres. In following this course we shall commence with the facts most generally known and best authenticated, and gradually find ourselves in regions less familiar and less determined, but from the physician's point of view of more importance and of greater interest. The very fact that the central portions of the visual tracts are still the subject of much uncertainty makes it more enticing to study them; it is at the same time important that we should be familiar with what is already known, in order that cases may be carefully recorded and pathological examinations accurately conducted. So the physician may still help the experimental neurologist in the elucidation of much that is obscure.

The optic nerve is composed for the most part of fibres from the innermost layer of the retina which have collected together at the papilla and emerged from the eyeball by the porus opticus in its sclerotic coat; this aperture, it is to be remembered, is situated at a point about 3 mm. to the inner side of the posterior pole of the globe; here the fibres have become medullated and the

newly-formed nerve is surrounded by sheaths which become continuous through the optic foramen at the apex of the orbit with the three membranes covering the brain. The orbital portion of the optic nerve varies in length between 20 mm. and 30 mm.; the intra-cranial portion measures about 10 mm. Tracing it from the eyeball the nerve takes a sinuous course upwards, inwards and backwards; it is crossed on its upper side in a direction from behind, obliquely forwards and inwards by the ophthalmic vessels and the nasal nerve: it is immediately surrounded by the posterior ciliary vessels and the long and short ciliary nerves and is less directly enclosed by the cone of recti muscles, though these closely envelope it at their fibrous origin; it is pierced obliquely on its lower side about 12 mm. behind the globe by the central artery and vein of the retina; both divisions of the third nerve, but more particularly the lower division, as well as the sixth nerve, lie immediately in relation to the optic nerve after they have entered the orbit by the sphenoidal fissure and passed between the two heads of origin of the external rectus muscle; the ciliary ganglion, seated upon the large branch which the lower division of the oculo-motor gives to the inferior oblique muscle, lies to the outer side of the optic nerve, between it and the external rectus. In the intra-cranial portion of its course the optic nerve has the ophthalmic artery below and to its outer side; the artery maintains its relationship and at the optic foramen is enclosed in the sheath given to the nerve by the dura mater; as soon as the orbit is reached the artery regains its freedom by perforating the fibrous covering.

The optic chiasma is the point at which the optic nerves meet, and their fibres rearrange themselves to form the optic tracts. In shape and course of fibres the commissure may perhaps be not inaptly compared to what is known to railway engineers as a diamond crossing of

the permanent way ; flat in shape, it rests in a groove on the olivary eminence of the sphenoid bone, and is situated at the junction of the anterior and inferior walls of the third cerebral ventricle, and at the most dependent point of this cavity ; indeed, it contributes to form the wall of the ventricle ; immediately behind it is the tuber cinereum, from which by the stalk of the infundibulum the pituitary body hangs, at a lower level, in the hollow of the sella turcica. In the lateral angle of the optic chiasma ascends on either side the internal carotid artery, emerging from the cavernous sinus and giving origin to its ophthalmic branch. To the outside of the commissure is seen on the under aspect of the cerebral hemisphere the anterior perforated spot ; this area is bounded antero-internally by the inner root of the olfactory lobe, which is therefore in close proximity to the chiasma, and postero-internally by the optic tract. The body of the sphenoid bone, after puberty, becomes hollowed by the development of its two air-cells, lined by mucous membrane, in communication with the nose, separated from each other by a more or less complete osseous septum and gradually enlarging as age advances by absorption of the cancellous bone ; these air-cells, therefore, extend backwards immediately beneath the optic commissure, and in relation to their lateral bony walls lie the intra-cranial portion of the optic nerve in front, and the cavernous blood sinus with its various contents more posteriorly.

The optic tract appears at the lateral angle of the chiasma, and runs backwards and outwards on the under aspect of the hemisphere between the tuber cinereum and the anterior perforated space ; the tract thus forms the antero-lateral boundary of the interpeduncular space and then becomes converted into a more flattened band, crossing and closely attached to the upper part of the cerebral peduncle (fig. 7, p. 33) ; bending around the outer side

of the peduncle, hidden by the temporo-sphenoidal lobe, it passes beneath the posterior part of the optic thalamus, and widening out is divided by a longitudinal groove into a smaller mesial and a larger lateral root (fig. 2). The smaller root, as far as it can be followed by coarse dissection, curves round the crusta of the cerebral peduncle and loses itself beneath the internal geniculate body ; the larger root can be followed by the naked eye as far as the pulvinar of the optic thalamus and the external geniculate body, and a portion of it runs into continuity with the brachium of the superior corpus quadrigeminum.

Further and more exact information about the visual pathways has been obtained by various methods, of which microscopical examination, pathological investigation and research into developmental processes and degenerative changes, the result of traumatism or disease, form the chief. It has been possible to establish beyond doubt the existence in the optic nerve of the papillo-macular bundle of fibres, upon which man depends for the acuteness of direct vision. The total number of fibres in the human optic nerve probably does not exceed 500,000, packed together in about 800 bundles by well-defined trabeculæ of connective tissue in continuity with the pia matral sheath of the nerve. The papillo-macular fasciculus is composed of nerve fibres, which originate as the axis cylinder processes of the ganglionic cells so abundantly found at the macula and the adjacent central part of the retina ; so important is this region that this bundle constitutes about one-third of the whole optic nerve ; near to the globe its fibres occupy a wedge-shaped area, which is seen in transverse sections to have its apex at the central vessels and its base in the lower outer segment of the nerve's circumference ; traced onwards towards the optic foramen the macular bundle is found to lose its wedge shape as its fibres gradually arrange themselves in a more central and dorsal position in the nerve.

In many mammals and in all vertebrates below mammals, complete decussation of the optic nerves takes place, and in anatomical works statements are to be met with that complete crossing of the optic nerves has been observed in the human subject, but examples of this condition must be extremely rare. In man the fibres which cross in the optic chiasma are those derived from the nasal half of each retina, while those derived from the temporal half pass uncrossed into the optic tract of the same side ; it is found in cases in which the fibres of the papillo-macular bundle

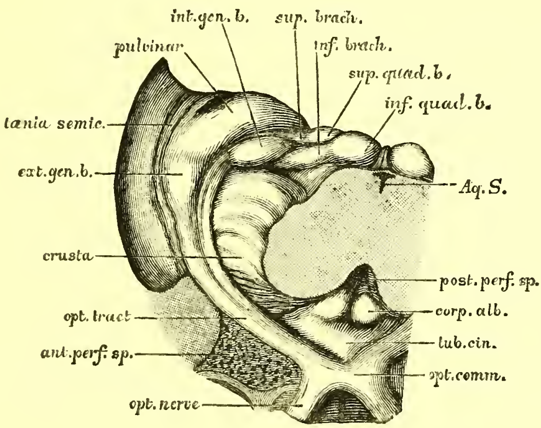


FIG. 1.
The Origin and Relations of the Optic Tract (from Prof. Thane, "Quain's Anatomy"), viewed from below, a section having been made across the upper limit of the pons varolii.

have undergone pathological degeneration that they can be identified, even as far as the optic tracts ; in the chiasma the macular fibres occupy a dorsal position and thus lie close beneath the brain ; each bundle undergoes a partial decussation in the commissure ; some of its fibres cross to gain the opposite optic tract, while the remainder are more directly continued into the optic tract of the same side ; in each tract the uncrossed fibres of one macular bundle are joined by the crossed fibres of the macular bundle of the opposite side, and there is thus reformed a complete but mixed macular bundle which occupies the centre of each optic tract.

A few fibres which pass to the optic nerve of the same side are said to be added to the optic tract from a collection of gray cells situated in the interpeduncular space by the side of the tuber cinereum, and called by Meynert the basal optic ganglion; these, and also the fibres which connect the two internal geniculate bodies by running in the mesial sides of the tracts and posterior part of the chiasma have probably no relation to vision; neither set is found to have undergone any change in cases in which all other fibres of the optic tracts have suffered complete atrophy; the fibres just referred to, which connect the two internal geniculate bodies, have been called the inferior

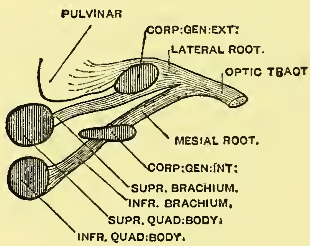


FIG. 2.

Diagram of the roots of the optic tract (after Cunningham).

commissure or commissure of Gudden. A similar set of fibres in each optic nerve, and forming an anterior bundle in the chiasma, was formerly thought by Stilling to form a commissure uniting the two retinæ; the existence of such retinal association fibres is doubtful. In the optic tract, the constituent parts of which we have now considered, the uncrossed fibres appear to be mesially placed, while the crossed fibres occupy a more peripheral and lower position.

Now that we come to unravel the optic tract with a view to determining the immediate destination of its fibres, we are confronted with many diverse opinions. Taking first into consideration the path by which afferent

impulses pass to produce reflex contraction of the pupils, Bechterew advanced the view that centripetal fibres for the light reflex of the sphincter pupillæ passed to the more anterior parts of the third nerve nuclei direct from the optic chiasma across the floor of the third ventricle ; this view has not been generally accepted. Darkschewitsch and Mendel describe fibres which they trace from the optic tract in the region of the external geniculate body to the ganglion habenulæ, a collection of nerve cells in the trigonum habenulæ ;* from here, in their view, fibres pass to the stalk of the pineal body and thence by the ventral part of the posterior commissure to the oculo-motor nucleus of the opposite side ; they regard this as the afferent path for the impulses which produce the reflex changes in the size of the pupil, and their view at any rate is not disproved.

Meynert's conclusion as to the course of the pupillary fibres is the most simple and the most easily understood ; the fibres of the optic tracts which reach the anterior corpora quadrigemina spread inwards and obliquely backwards over their surface ; other fibres in physiological, if not in direct anatomical continuity with these, are to be found leaving these gray nuclei on their deep aspect ; they tend to take a ventral course and are assumed to form communications with the nuclei of the eye muscle nerves ; that this communication has been directly traced out in its whole length and indisputably established is not claimed, as at one point the fibres in question are hardly to be distinguished from the arching fibres of the fillet.

Things become even more involved when we proceed to consider the fibres which convey visual impulses from

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* This name is used to describe a small depressed triangular area between the pulvinar of the optic thalamus and the peduncle of the pineal body.

the primary basal connections of the optic tract to the cortical visual centres, and naturally so when we reflect that neither the point of departure nor the destination of these so-called pallio-tectal fibres is reliably and finally determined ; it seems, however, to be universally agreed that these fibres occupy the hinder part of the posterior limb of the internal capsule, and that having traversed this isthmus they widen out as the optic radiations in passing to the cortical visual centre which is generally regarded as being situated on the internal aspect of the occipital lobe, *i.e.*, the cuneus, and more particularly in the immediate neighbourhood of the calcarine fissure. There are those who hold that the angular gyrus is, in man, an important visual centre ; Ferrier and Sharkey, particularly, have contended for this view, and Gowers, in lecturing on subjective visual sensations, adopted this parietal centre in explanation of some of the cases which he cited. Let us, however, first try and trace the visual fibres from or through the primary basal ganglia with which the optic tract makes communications, until we land them safely in the internal capsule—it must be remembered that the posterior limb of the internal capsule is bounded on its inner side by the optic thalamus and externally by the lenticular nucleus of the corpus striatum ; the pulvinar is the posterior tubercle of the thalamus, and the nucleus of each of the geniculate bodies is directly continuous with the gray matter of the optic thalamus. Wernicke considers that some fibres, constituting the so-called fibrillary bundle, pass directly from the tract through the posterior part of the internal capsule without relation to the primary optic ganglia. Schäfer describes fibres which pass out of the lateral margin of the pulvinar into the posterior limb of the internal capsule, and at first hold a curved course round the posterior horn of the lateral ventricle before radiating towards the occipital cortex ; he says these fibres

are continuous with others which have passed from the optic tract to the pulvinar. Flechsig, tracing the fibres of the optic tract by their myelination, finds them to pass directly to the lateral geniculate body and thence to the superior corpus quadrigeminum, but could detect none running directly to the thalamus; from the lateral geniculate body a stout bundle is traced to the pulvinar, but the fibres of which it is composed for the most part course through this nucleus to join the optic radiations and thus to reach the margins of the calcarine fissure. There is then good authority for the view that some of the tract fibres pass into the internal capsule direct from the tract, perhaps by threading their way between the cells of the pulvinar nucleus, but without interruption of their anatomical continuity.

As regards the further path of impulses conveyed by the tracts to the anterior corpora quadrigemina, the fibres which connect these ganglia with the cortex cerebri appear to leave them chiefly on their mesial aspect, and to be the axons of cells occupying the gray matter which intervenes between the superficial and deep layers of white fibres found in the quadrigemina and already referred to in explaining Meynert's view of the pupillary fibres.

According to Monakow 80 per cent. of the fibres of the optic tract pass to the lateral geniculate body and the pulvinar, where they terminate; new fibres arise in these nuclei and so continue the optic path to the occipital lobe, where it terminates in the cuneus and the lips of the calcarine fissure.

Ramon y Cajal finds that the fibres which pass from the lateral geniculate body are collected into a bundle situated at the upper and outer part of the cerebral peduncle and continued into the internal capsule, whence they radiate into the occipital lobe and here appear in the gray cortex as the stripe of Gennari, to which we shall have occasion

again to refer ; the fibres of the optic tract which pass to the anterior corpus quadrigeminum, or at least some of them, in Ramon y Cajal's opinion serve to convey impulses for the reflex movements of the eyeballs and cannot therefore be traced to any part of the cerebral cortex.

The brain of an adult anophthalmic idiot has recently been examined in America with the following interesting result : Complete absence of eyes, optic foramina, optic nerves, chiasm and tracts was accompanied by entire absence of the external geniculate bodies and some slight want of development of the posterior ends of the optic thalami ; there appeared to be a diminution in the number of fibres passing from the thalami into the internal capsules ; the anterior corpora quadrigemina were not unusually small ; the cuneus was a very small lobule and the calcarine fissure short. In confirmation of the above observations it has been proved that loss of an eye in a newly-born puppy results in diminished development of optic nerve and tracts, of occipital lobes, of the superficial white matter of the anterior corpora quadrigemina, of the lateral geniculate bodies and of the pulvinar tubercles of the thalami ; the internal geniculate bodies and the posterior corpora quadrigemina show no want of development as the result of the experiment.

It seems generally agreed that in the optic radiations and the visual part of the posterior limb of the internal capsule there are corticifugal fibres connecting the occipital cortex with the basal nuclei ; they pass mainly to the pulvinar and anterior corpus quadrigeminum and are irregularly mingled with the corticipetal visual fibres whose course we have been trying to unravel.

As regards the inferior corpora quadrigemina, their cells are found to be brought into intimate relation with the nuclei of origin of the cochlear nerves of the opposite side by means of the lateral fillet ; the inferior corpora

quadrigemina are only found in mammals possessed of well-developed spirally coiled cochleæ and their function may therefore be taken to be a purely auditory one.

To sum up : The roots of the optic tract pass to the anterior corpus quadrigeminum, the external geniculate body and the pulvinar tubercle of the optic thalamus ; through the cells of the first-named ganglion communication is established particularly with the motor nuclei, but a few centripetal fibres may be traced by way of the internal capsule to the cortex cerebri ; many corticifugal fibres pass to the anterior corpus quadrigeminum from the gray cortex. The visual fibres of the tract connect by synapsis mainly with the cells of the pulvinar and external corpus geniculatum ; the corticipetal fibres from either of these two basal nuclei form, in the hind limb of the internal capsule *en route* for the occipital cortex, a bundle larger than the optic tract itself, the fibres from the external corpus geniculatum being more numerous than those from the pulvinar ; by means of synapsis these two basal ganglia are able to act as spreaders of the visual impulses.

*Visual Centres.*—All are agreed that on the inner aspect of the cortex of each occipital lobe there exists a half vision centre ; that in the right hemisphere corresponds with the right half of each retina and therefore receives the impressions excited by objects situated in the left half of each visual field, and *vice versâ* for the centre in the left hemisphere ; destruction or disease of one of these centres causes lateral homonymous hemianopia. Different views are held, however, as to the extent of this area which, on the inner aspect of the occipital lobe, is devoted to the function of sight. Henschen holds that the centre is a very limited one, and comprises only that part of the cortex which is sunk within the calcarine fissure ; he claims that the dorsal quadrant of each retina is represented in the

upper lip of the fissure, the ventral quadrant in its lower lip, and that the macula is provided for in the forepart of the floor of the sulcus. Others extend the visual area over the cuneate lobule more generally, and some maintain that it spreads around the posterior pole of the hemisphere to the convex outer surface of the occipital lobe. Ferrier and Sharkey think the angular gyrus of the infra-parietal lobule on each side a more important visual centre than any that exists in the occipital lobe, inasmuch as they consider it to contain the special region for the central direct vision of the opposite eye, and perhaps to some extent of the eye of its own side, while only the correlated halves of peripheral portions of the retinæ are represented in the rest of the occipito-angular region.

Ferrier's conclusions are founded mainly on the results of extirpation experiments on the cortex of the angular gyrus, while Sharkey is led to take the same view by pathological observations. In support of their respective views on the visual centres Ferrier and Turner claim to have traced fibres of the optic radiations to the angular gyrus as well as to the occipital lobe, while Henschen and Flechsig hold that the fibres pass chiefly, if not entirely, to the cuneus and lips of the calcarine fissure.

Schäfer is of opinion that each macula is represented in both hemispheres. Wernicke discovered that fibres of the optic radiations pass just beneath the gray matter of the angular gyrus *en route* for the occipital region ; it seems probable that it is damage to these fibres which accounts for the results obtained by Ferrier in his extirpation experiments on the posterior part of the infra-parietal lobule.

The two occipital lobes are put into association by fibres which help to form the eminence in the inner wall of the posterior horn of each lateral ventricle situated above the hippocampus minor and known as the bulb of

the cornu ; these fibres cross the great longitudinal fissure of the brain transversely in the lower part of the splenium of the corpus callosum, the big commissure between the hemispheres ; according to Ferrier and Turner the two angular gyri are also associated by commissural fibres in

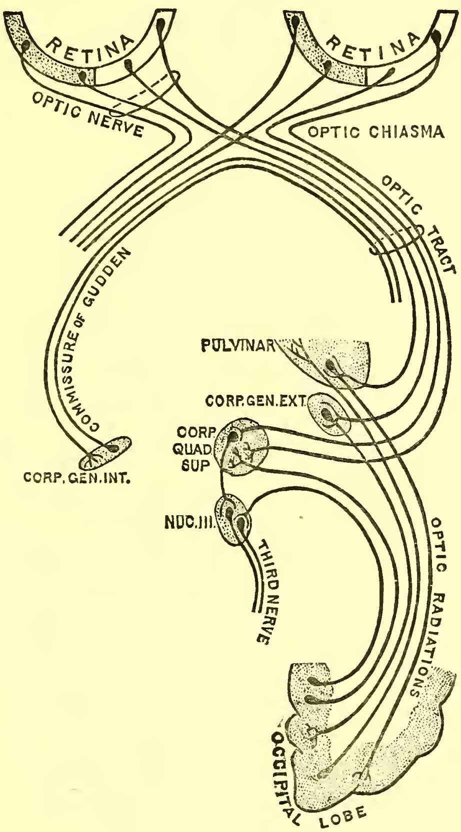



FIG. 3.

Diagram of the central connections of the optic nerve and optic tract (after Cunningham).

the corpus callosum. Fibres holding an antero-posterior course connect the occipital and frontal lobes, and shorter association fibres unite the visual areas to nearer parts of the cerebral cortex.

Bolton has recently published some excellent work on the microscopical anatomy and pathology of the occipital

centres for vision. He found that the calcarine fissure usually bifurcated posteriorly into an upper and a lower limb ; the upper limb passed in about one half of the cases on to the external surface of the occipital lobe ; the lower limb was confined to the inner aspect of the brain in less than half of the specimens he examined ; in rather more than one half of the brains the lower limb passed either below the occipital pole on to the tentorial aspect, or to the pole, or by extending beyond or above the pole terminated on the outer convex surface of the hemisphere. The cuneal sulcus is a small fissure usually present in the cuneate lobe ; it takes its course parallel to and just above the posterior part of the calcarine fissure. The vascular supply of this area is afforded by branches of the posterior cerebral artery. The posterior cerebral gives off an occipital artery which soon divides into branches occupying the limiting sulci of the cuneate lobe, viz., the internal parieto-occipital and the calcarine ; the former of these very soon gives origin to a small secondary branch, the cuneal, which runs in the cuneal fissure parallel to the calcarine artery. The above description of the arterial supply on the inner aspect of the occipital lobe agrees with that given by Monakow ; Bolton publishes examples of lesions of the cuneal and calcarine arteries singly, and of the cuneal jointly with the calcarine or with the parieto-occipital in two other brains which he examined.

Bolton found that over the occipital lobe generally, the cortex may be split histologically into the following five layers :—

(1) Outer layer of nerve fibres.

(2) Layer of pyramids.

(3) Layer of granules containing pyramids, or granule layer.

(4) Inner layer of nerve fibres.

(5) Layer of polymorphic cells.

The calcarine, or visuo-sensory portion of the occipital cortex has a middle layer of nerve fibres, the line of Gennari, running through number (3), and thus splitting it into two laminæ ; the limits of this specialised calcarine cortex are sharply defined ; the line of Gennari abruptly ceases and the single granule layer is re-established. By laborious microscopical work, Bolton has ascertained the exact limits of that part of the occipital cortex which presents this special histological structure and he regards it as the area devoted to the visual sense. He found the area to be approximately pear-shaped, the thick end being at the pole of the hemisphere and the stalk directed anteriorly ; it comprises (*a*) the posterior part of the calcarine fissure, extending to and not infrequently round the occipital pole ; (*b*) the middle portion of the calcarine fissure, and extending thence up to the parallel cuneal sulcus and down to the collateral fissure ; (*c*) the lower lip of the stem of the calcarine fissure below the isthmus of the limbic lobe, where the area tails off anteriorly.

This area of special lamination Bolton found to be much decreased in extent in cases of long-standing blindness ; the calcarine fissure was diminished in depth and its bounding convolutions were reduced in size. In cases of optic atrophy of long duration the line of Gennari was attenuated to one half its normal thickness ; in anophthalmos the thickness of the line of Gennari and the outer stratum of the granule layer measured together was not more than two-thirds of the normal, while the same dimension of the other laminæ of the specialised cortex was unaltered ; the total area, however, of the visual cortex was restricted as regards both extent and distribution.

Bolton is of opinion that Sharkey is probably right in thinking that lesions confined to the outer surface of the hemisphere can cause hemianopia ; the visuo-sensory area and the calcarine fissure frequently pass round the posterior

pole of the hemisphere and encroach to some extent upon its external surface ; a lesion on the convexity may therefore quite possibly give rise to more or less complete paralysis of the half vision centre without going deep enough to implicate the optic radiations : at the same time Bolton will not admit the existence of a vision centre in the angular gyrus, and his work has led him to distrust any statement as to the extent of brain cortex involved in a pathological lesion, unless it is based on the fullest microscopical examination.

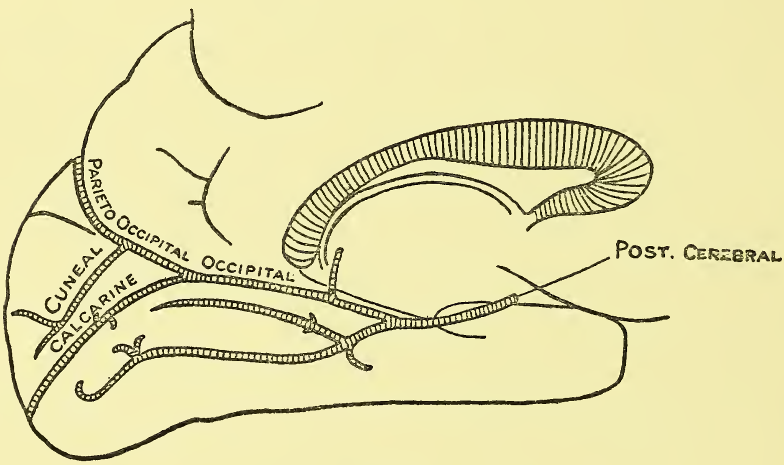



FIG. 4.

Cuneate lobule, and adjacent convolutions on the mesial aspect of the cerebral hemisphere, showing the fissures occupied by the nutrient arteries to this part of the cortex (after Bolton).

*A Visual Memory Centre* is considered to exist in man in the occipital lobe ; its precise situation and limits are not defined, but it is undoubtedly distinct from the cortical centre for vision, though in close anatomical proximity to it ; when its function is impaired the condition of visual amnesia or mind-blindness results ; the patient is no longer able to recognise objects by the unaided sense of sight alone, or to describe the appearances of objects with which he was formerly perfectly familiar. It will be easily understood why visual amnesia is frequently accompanied by homonymous hemianopia.

In the presence of a limited lesion situated on the path between the vision centre and the visual memory centre, the patient can recall and describe familiar objects but cannot recognise any of them by sight alone when they are brought before his eyes.

Pathological evidence seems to have satisfactorily proved that the condition of visual sensory aphasia known as word-blindness, in which the patient cannot understand a written or printed word and therefore cannot reproduce it in speech, is dependent on a lesion of the left angular gyrus.

There must therefore undoubtedly be association fibres running between the vision centre and the visual memory centre, and others which course from the visual memory centre through the left infra-parietal lobule *en route* to the speech centre in the third left frontal lobe.

Hinshelwood takes the view that the centre in which are stored the visual memories of letters and words is itself situated in the left infra-parietal lobule ; this implies that it is a centre distinct from that for the visual memories of other objects ; Hinshelwood and Nettleship have described cases of congenital word-blindness in which the visual memory centre for words, wherever situated, presumably is undeveloped.

Association fibres generally are found to be particularly late in acquiring their myelin sheaths and are, in consequence, more easily identified in the developing brain.

As regards the *blood supply* of those parts of the brain we have had under consideration, the following account may be found useful :—

The internal carotid artery in turning upwards out of the cavernous sinus lies at first to the inner side of the anterior clinoid process, pierces the dura mater and then gives off the ophthalmic artery ; at the same point it gives nutrient twigs to the optic chiasma and the optic nerve

of its own side ; it furnishes the posterior communicating artery to the circle of Willis ; supplies the anterior choroid branch and divides into the anterior and middle cerebrals. The middle cerebral, by means of branches which enter the substance of the hemisphere at the anterior perforated spot, supplies the caudate and lenticular nuclei of the corpus striatum and the anterior limb of the internal capsule. The anterior choroid branch of the internal carotid runs backwards parallel to the posterior communicating artery but more laterally placed, so that it occupies the groove between the temporal lobe and the crus cerebri ; in its course backwards it gives branches to the optic tract and to the uncinate convolution and finally reaches the choroid plexus in the descending horn of the lateral ventricle ; the anterior choroid artery also supplies a few central branches, viz., the small twigs to the posterior limb of the internal capsule ; this neglected artery is therefore of first-rate importance to the visual pathways. The posterior communicating artery gives twigs to the most anterior part of the optic thalamus ; in the greater part of its extent, however, and entirely in its posterior visual portions the thalamus derives its nutrition from the posterior cerebral artery by two sets of branches ; these sets enter the hemisphere, one to the inner side of the crus cerebri in the interpeduncular space at the posterior perforated spot, the other to the outer side of the crus.

The posterior communicating artery is sometimes found to be a branch from the first part of the middle cerebral artery instead of from the internal carotid. The posterior cerebral not infrequently is derived from the internal carotid by an enlargement of the posterior communicating artery ; in such a case the circle of Willis will be incomplete behind on the side of the irregularity, or only joined up with the basilar artery by a very slender twig ; the possible influence of this variation on the symptoms

in a case of thrombosis of the basilar will be appreciated. The important anterior choroid artery is also liable to be irregular ; its single trunk is sometimes represented by several branches, and it has been seen to arise as a branch either of the middle cerebral or of the posterior communicating artery.

The crura cerebri are nourished from the posterior communicating and the posterior cerebral arteries.

The corpora quadrigemina, to which recently the names anterior and posterior colliculi have also been given, and the corpora geniculata derive their blood supply from the posterior cerebral arteries, but twigs from the superior cerebellar branches of the basilar are also found to be given to the inferior corpora quadrigemina.

The nutrient vessels of the pons varolii are offshoots of the basilar artery. The arteries to the medulla oblongata are supplied by the vertebrals and their branches, the anterior spinal and posterior inferior cerebellar arteries ; the twigs enter mainly along the nerve roots and the anterior median raphe.

The blood supply of the occipital centre has been alluded to ; of the branches of the posterior cerebral distributed in this region the calcarine artery is the most important ; it is found to follow the calcarine fissure to the posterior pole of the hemisphere, around which it usually turns to gain the outer aspect of the occipital lobe. No anatomical evidence can be adduced in support of the view that the macular centre, supposed to occupy the more anterior part of the calcarine fissure, is more freely supplied with blood than other parts of the occipital visual cortex ; the hypothesis has been suggested as a possible explanation of the fact that in cases of homonymous lateral hemianopia of cortical origin direct vision is usually preserved.

## CHAPTER II.

### The Centres for Ocular Movements.

The centre which controls the movements of the eyes is found by Sherrington in the monkey to be situated immediately anterior to the præcentral sulcus in the frontal lobe. Behind the præcentral sulcus, *i.e.*, in the ascending frontal convolution, below that part of it devoted to the movements of the upper extremity, and above the centres for the mouth, face and tongue, is a small area which controls those movements of the eyelids which the orbicularis palpebrarum muscle effects; this small isolated centre is seen, therefore, to be in immediate proximity to those responsible for the facial movements, and the peculiarity of the innervation of the orbicularis palpebrarum will be recalled in this connection. The situation of these centres should be carefully realised; it may have some bearing on the complete picture and accurate diagnosis of certain cases of Jacksonian epilepsy.

Drs. Ferrier and Aldren Turner performed an experiment consisting in the removal of both the frontal lobes and angular gyri of a monkey; these were destroyed first on the left, and after a few days' interval, on the right side. Each operation produced a temporary conjugate deviation and paralysis, the eyes being directed towards the lesion; there was no ptosis, and no interference with the opening and closing movements of the lids. Ferrier and Turner concluded that ophthalmoplegia, in its proper sense of impairment of ocular muscles, does not result from purely

cerebral lesions; they do not of course deny that movements of the eyes can be produced by stimulation of certain parts of the excitable cortex.

Sherrington finds that stimulation of the occipital cortex produces movement of the eyes, and does so, not by utilising association fibres passing to the Rolandic area, but by direct passage of stimuli to the nuclei of the motor nerves of the eyeballs, through some of the corticifugal fibres whose existence we have already described; these fibres are associated with the afferent visual fibres passing to the same region of the cortex, and lie therefore in the most posterior portion of the hind limb of the internal capsule. The fibres passing to the base of the brain from the oculo-motor cortex of the Rolandic area occupy the most anterior position of all the fibres composing the anterior limb of the internal capsule.

There seems now to be little doubt that lesions of the corpora quadrigemina may sometimes exist without any affection of vision. These bodies must not, however, in all probability be regarded as subsidiary centres co-ordinating ocular movements; though disorders of eye movements are among the most conspicuous of the symptoms in cases of lesion of the corpora quadrigemina, the ocular paralyses are considered to be "distant symptoms"; when the colliculi are involved in disease, loss of movements of the eyes in the vertical plane, either upward or downward, or both, is usually observed; rarely one eye becomes displaced up and the other down, and this displacement may be regarded as pathognomonic. Ataxy or vertigo is a commonly associated symptom and may cause the physician to suspect cerebellar disease; in cases of cerebellar mischief paralysis of the sixth or some of the succeeding nerves, may help to indicate the lower situation of the lesion; in disease of the corpora quadrigemina definite paralysis of the third and fourth nerves is early present, or may probably soon

develop, while the later cerebral nerves will be likely to escape. In lesions suspected to be in the quadrigeminal region both the Argyll-Robertson phenomenon and the hemiopic pupil should be carefully examined for ; the undoubted presence of either may be taken to confirm the diagnosis.

*Conjugate Deviation* of the eyes may be due to a lesion either in the hemispheres or at the base of the brain. It is seen as a transitory phenomenon in cases of hæmorrhage into the motor pathway of the hemisphere giving rise to hemiplegia ; when the pathological process is a destructive one the eyes turn away from the paralysed side of the body or are said to look towards the lesion ; in hemiplegic patients the symptom may be due to temporary suspension of the function of the hemisphere. In the presence of an irritative lesion of the motor cortex the eyes deviate in the opposite direction, *i.e.*, they look away from the lesion and towards the side of the body which is convulsed.

Experimental irritation of one optic lobe is found in animals to cause conjugate deviation of the eyes towards the side to which the stimulus is applied. Abiding conjugate paralysis in man is indicative of a nuclear lesion, and the eyes turn away from the side on which the lesion is situated. It is, however, undoubted that paralysis of one external rectus muscle may be the sole result of a small lesion involving the nucleus of its sixth nerve, a convergent squint being in evidence, but no bilateral conjugate deviation ; endeavours have been made to find an explanation of this apparent discrepancy ; one explanation offered is that conjugate paralysis is the result if the lesion leaves the sixth nerve nucleus free, but implicates, in the posterior longitudinal bundle, those fibres which connect it with the third nerve nucleus of the opposite side, while a true nuclear lesion produces an abducens paralysis ; the other theory assumes that a lesion involving the nuclear cells of

the sixth nerve produces conjugate paralysis, and that paralysis of the external rectus as the sole result is only produced by a lesion involving the fibres of the abducens as they traverse the pons varolii between the nucleus and the superficial origin of the nerve.

One case of pontine tumour that I had the opportunity of observing under the care of the late Dr. Bristowe presented conjugate paralysis, the eyes being displaced to the side opposite to that on which the tumour was developing; as the growth enlarged and traversed the mid-line of the pons, conjugate paralysis in the reverse direction was added, *i.e.*, the eyes were observed to have returned to the primary position, and the only movements of them which the patient could then produce were those in the vertical plane; *post-mortem* examination afforded an opportunity of confirming the diagnosis and the accuracy of the explanation which Dr. Bristowe had furnished.

Physiological experiments on the hemispheres of monkeys have shown that conjugate deviation of head and eyes away from the side on which the irritative stimulus is applied may be obtained by using the electrodes to many different parts of the cortex, *e.g.*, to the region of the motor area immediately in front of the præcentral sulcus, to the neighbourhood of the parallel sulcus in the temporo-sphenoidal lobe or to the convex aspect of the occipital lobe; in the neighbourhood of the præcentral furrow, the head and eyes turn down as well as to the opposite side if the cortex adjoining the upper part of the fissure be stimulated; up and to the opposite side, when the area at its lower end is irritated and more truly in the lateral direction when the part near the angle in the middle of the fissure is excited; similar results are obtainable from the different levels on the convex aspect of the occipital lobe. The head and eyes turn down and to the opposite side when the electrodes are applied to the upper end

of the internal parieto-occipital fissure on the mesial surface of the hemisphere; and the eyes turn directly to the opposite side when the visual area adjoining the calcarine fissure is stimulated.

Disease of the lateral lobe of the cerebellum may result in conjugate deviation of head and eyes away from the lesion and give rise to nystagmus, in which the jerks take place toward the side of the lesion with a slower return movement; other associated symptoms may be vertigo, scanning speech and swaying of head; unsteadiness in standing and walking, the loss of equilibrium not being aggravated by closure of the eyes, *i.e.*, no Romberg's sign; weakness of limbs, particularly of the arm, on the side of the lobe affected may be met with, while there is no disorder of cutaneous sensibility and no psychical disturbance; in the presence of tumour or abscess the more general symptoms of optic papillitis, headache and persistent vomiting, subnormal temperature and slow pulse may be expected.

# CHAPTER III.

## Cranial Nerves: Their Nuclei, Superficial Origin, Course and Distribution.

The nucleus of the sixth nerve lies beneath the floor of the anterior portion of the fourth ventricle ; it is visible on examining the floor of this ventricle in the brain of a young child as a rounded swelling in the forepart of the funiculus teres. The fibres of the sixth nerve leave the nucleus on its mesial and dorsal aspect and run almost a straight course through the substance of the pons to reach the surface in the groove between the upper end of the anterior pyramid of the medulla and the lower limit of the pons varolii.

The fourth nerve nucleus is found in the floor of the iter, at a level corresponding with the anterior half of the posterior quadrigeminal bodies : the fibres of origin of the nerve run in the walls of the iter half-way round its circumference before reaching their point of emergence ; they take a course at first outwards, then backwards, and finally dorsalwards and inwards, to decussate with their fellows of the opposite fourth nerve before appearing on the dorsal aspect of the brain (the only cranial nerves which do so), at the valve of Vieussens.

The third nerve nucleus is situated in the floor of the iter immediately above that of the fourth ; its lower limit corresponds in level with the groove between the anterior and posterior corpora quadrigemina, its total length being about one-third of an inch ; the forepart of this large nucleus ex-

tends beyond the iter into the back part of the floor of the third ventricle ; the most anterior and dorsal part of the third nerve nucleus is the source of the nerve fibres for the ciliary muscle and the sphincter pupillæ, the cells devoted to the innervation of the latter muscle forming the more laterally placed group of these two subdivisions ; further differentiation of the nucleus into parts concerned with individual extra-ocular muscles cannot be said to be proved. Schäfer states that some fibres from the posterior and dorsal part of one third nerve nucleus decussate with corresponding fibres from the fellow nucleus of the opposite side, and are believed to be destined for the opposite internal rectus muscle ; most of the fibres from the nucleus run, however, a short, straight and direct course, to appear superficially in the interpeduncular space along the oculo-motor groove of the crus cerebri.

The position of the seventh nerve nucleus and the course of its fibres is indicated in fig. 6. It is of importance because of the relation of its root fibres to the sixth nucleus, and also because fibres are added to the facial nerve from the third nerve nucleus ; these appear to be the fibres which the facial distributes to the frontalis, orbicularis palpebrarum and corrugator supercilii muscles ; they descend from the oculo-motor nucleus in the posterior longitudinal bundle and join the issuing portion of the seventh root.

The posterior longitudinal bundle is derived from fibres of the anterior pyramidal tract ; beneath the floor of the fourth ventricle it lies alongside of the median raphe, between the central gray matter of the ventricle floor and the reticular formation ; it thus passes immediately beneath the nuclei of the seventh, sixth, fourth and third cranial nerves, and some of its fibres have been traced upwards into the optic thalamus. The fibres of the posterior longitudinal bundle receive their myelin sheaths very early and

are in consequence easily differentiated. We have seen that the bundle contains descending fibres passing from the third nerve nucleus to join the seventh nerve of the same side ; fibres from the abducens nucleus are also considered to run an ascending course in it to join the issuing fibres from the fourth and third nuclei of the same side ; the two posterior longitudinal bundles are separated from one another only by the median raphe and an interchange of fibres between the two bundles can be recognised ; in this way probably the sixth nucleus of one side is brought into association with the third nucleus of the opposite side, an association which is all important in producing harmonious lateral movements of the two eyes.

*The Third Nerve* (oculo-motor).—The third nerve appears in ten or fifteen bundles on the inner side of the crus cerebri, in the line of the oculo-motor groove which runs upwards and outwards, commencing immediately above the pons ; the nerve passes between the superior cerebellar and posterior cerebral branches of the basilar artery and takes a direction forwards to the outer side of the posterior clinoid process of the basi-sphenoid bone ; just anterior to this process it perforates the dura mater in the small triangle bounded by the free and attached borders of the tentorium cerebelli as they pass to the anterior and posterior clinoid processes respectively. The third nerve thus enters the outer wall of the cavernous sinus. While passing forwards in the wall of the sinus the third nerve forms communications with the cavernous plexus of the sympathetic and the ophthalmic division of the fifth nerve. Before leaving the wall of the sinus the third nerve divides into a superior and inferior division, and in this form enters the orbit on the outer side of the external rectus muscle by passing through the sphenoidal fissure ; at the fissure the upper and lower divisions of the third are separated by the nasal branch of the first division of the

fifth nerve ; these three branches, together with the sixth nerve which in passing through the fissure has occupied the lowest position of the four, now come into relationship with the optic nerve by passing between the two heads of origin of the external rectus muscle. The upper division of the third within the muscular cone passes above the optic nerve and ascends to supply the superior rectus and the levator palpebræ superioris ; the nerves enter these muscles from below and that for the latter commonly

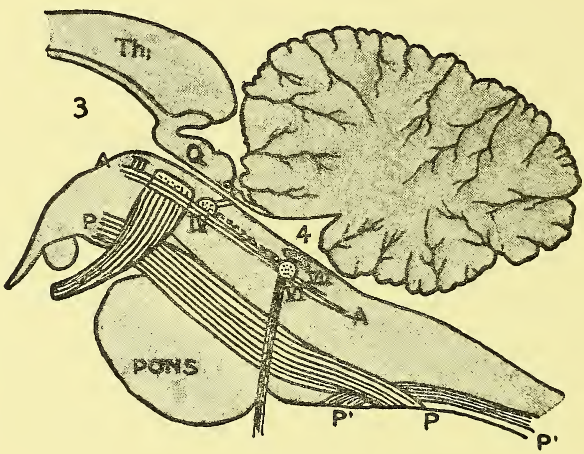



FIG. 5.

Diagrammatic section to show the nuclei of origin of the nerves of the ocular muscles. (After Fuchs, slightly modified to show the posterior longitudinal bundle and its immediate relation to the nerve nuclei.)

Th., thalamus ; Q., corpora quadrigemina ; P P, P′ P′, pyramidal tracts decussating at lower limit of medulla ; III., nucleus and root of third nerve ; IV., nucleus of fourth nerve, and its root skirting the iter to emerge dorsally, after decussating with its fellow, from the valve of Vieussens ; VI., nucleus and root of the sixth nerve—the nucleus lies immediately beneath the nucleus of the facial nerve VII. ; A A, posterior longitudinal bundle.

A lesion situated at the points of decussation of the third nerve root with the pyramidal tract or of the sixth nerve root with the pyramidal tract will produce a crossed paralysis.

perforates the superior rectus to reach the levator lying upon it. The lower division of the third nerve is distributed to three extra-ocular muscles, viz., the internal and inferior recti and the inferior oblique : the branch to the last-named muscle is the largest and usually gives filaments to the inferior rectus and sometimes perforates this muscle before entering the inferior oblique upon its posterior border. While passing downwards and

forwards on the outer side of the optic nerve the branch to the inferior oblique gives the short motor root to the ciliary or lenticular ganglion, which is, as it were, seated upon the nerve ; the motor fibres to the ciliary muscle and sphincter pupillæ are distributed by the short ciliary branches of the lenticular ganglion and are thus seen to be derived from the third nerve nucleus, running through the third nerve, its inferior division and motor branch to the inferior oblique and traversing the ophthalmic ganglion *en route.* The branch of the inferior division of the third nerve which supplies the internal rectus passes beneath the optic nerve to reach its muscle.

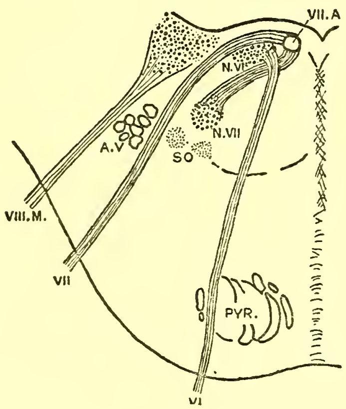



FIG. 6.

Plan of the origins of the sixth and seventh cranial nerves (adapted from Schwalbe). Transverse section of pons.

VII.A. At this point the root of the seventh nerve takes an ascending direction, and in the plan is therefore shown cut in section. A.V., ascending root of fifth nerve. SO., superior olive. PYR., pyramid. VIII.M., Mesial root of auditory nerve.

The third nerve has occasionally been found to give branches to the external rectus and even to supply this muscle entirely in the absence of a sixth nerve.

*The Fourth Nerve* (patheticus) emerges from the superior medullary velum close to the frænulum, immediately behind the inferior quadrigeminal body ; from this superficial origin the very delicate nerve runs outwards across

the superior peduncle of the cerebellum (processus ad testes) and then turns forwards round the outer side of the crus cerebri, here running parallel to and between the posterior cerebral and superior cerebellar arteries. It perforates the dura mater just in front of the apex of the petrous bone in the triangular area referred to in the description of the third nerve as bounded by the prolongations of the free and attached edges of the tentorium cerebelli ; at the point of perforating it is about a quarter of an inch behind and to the outer side of the corresponding aperture for the third nerve and is rather overlapped by the free border of the tentorium where this passes forwards to reach the anterior clinoid process. Occupying at first a position immediately below and to the outer side of the oculo-motor in the lateral wall of the cavernous sinus, the fourth nerve gradually ascends on the outer side of the third, so that it is placed at a higher level by the time the sphenoidal fissure is reached. In the fissure the frontal and lacrimal nerves lie in the same horizontal plane as the fourth, the lacrimal being the most external and the patheticus the most internal of the three ; all occupy a level above that of the highest of the other nerves which enter the orbit through the same fissure and which are arranged in a vertical series. Having gained the orbit the fourth nerve passes above the upper head of the external rectus muscle and above the superior rectus and levator palpebræ muscles to terminate in the superior oblique, which it enters close to its origin and on its orbital aspect ; the muscle it will be remembered runs close to the junction of the roof and inner wall of the orbit. While enveloped in the wall of the cavernous sinus the fourth nerve communicates with the cavernous plexus of the sympathetic on the carotid artery and with the ophthalmic division of the fifth nerve. No important variations of the patheticus have been described.

*The Sixth Nerve* (abducens) comes to the surface of the

brain in the groove between the anterior pyramid of the medulla and the pons ; for a little more than half an inch the nerve runs forwards and upwards between the antero-inferior aspect of the pons and the basi-occipital bone and

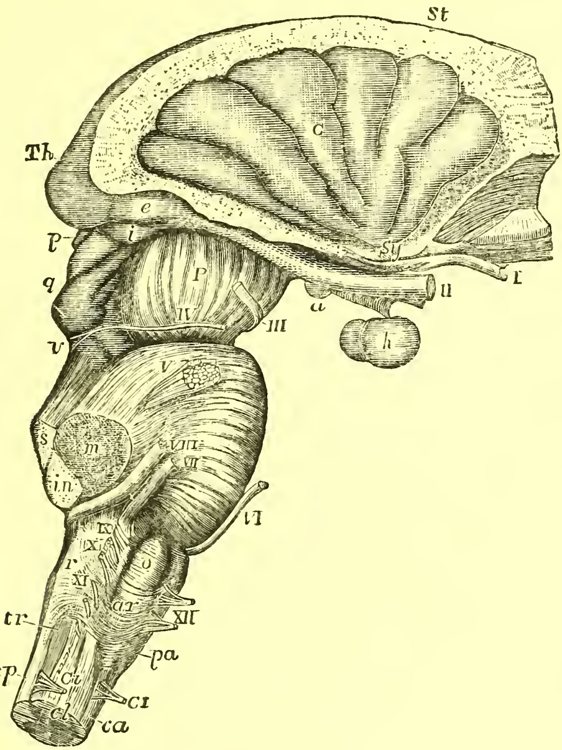



Fig. 7.

Lateral View of the Connection of the Cranial Nerves with the Brain (after Allen Thomson).

The corpus striatum and thalamus opticus have been preserved in connection with the convolutions of Reil and crura cerebri, while the remainder of the cerebrum has been removed.

St., upper surface of corpus striatum ; Th., back part of thalamus opticus ; C., central lobe or island of Reil ; p., pineal gland ; a., right corpus albicantium ; h., hypophysis cerebri or pituitary body ; P., peduncle or crus cerebri ; v., valve of Vieussens ; s., m., in., superior, middle and inferior peduncles of cerebellum cut short ; o., olivary body ; p.a., anterior pyramid of medulla ; e., external geniculate body ; i., internal geniculate body ; q., corpora quadrigemina with their brachia ; II., points to the optic nerves cut short just in front of the chiasma. The right optic tract and its basal connections are shown. The figures I.—XII. point to the cranial nerves. (From "Quain's Anatomy.")

then perforates the dura mater to the inner side of and slightly below and behind the perforation of the fifth nerve ; continuing its course it passes on the outer side of the inferior petrosal blood sinus, crosses the apex of the petrous bone and runs beneath the petro-sphenoidal

ligament to enter the cavernous sinus ; here at first it lies below the internal carotid artery and reaches the outer wall of the sinus only at its anterior part ; the nerve enters the orbit through the sphenoidal fissure forming the lowest of the vertical set of nerves, but it has below it the ophthalmic vein ; passing between the two heads of the external rectus the sixth nerve enters and supplies this muscle from its ocular surface. While in relation to the cavernous sinus the sixth nerve forms communications with the carotid plexus of the sympathetic and with the ophthalmic division of the fifth nerve. Absence of the abducens has been recorded, in which case the external rectus was observed to be supplied by a branch from the oculo-motor.

Exaggerated notions of the length of the cranial nerves between their superficial origins and the points at which they perforate the dura mater are apt to arise ; this portion of the third nerve measures little more than one inch ; the corresponding part of the small fourth nerve takes a very circuitous route, but is not longer than two inches ; of the sixth nerve the length of this intra-dural part is about an inch and a quarter. It is thus seen that only for a comparatively short distance are these nerves exposed to implication in meningeal disease.

*The Fifth Nerve* (trigeminus) appears at the lateral edge of the pons, considerably nearer its upper than its lower border in the shape of a smaller upper motor root separated by a slight interval from the larger lower sensory root : the two roots run forwards together and enter a recess in the dura mater, the cavum Meckelii, situated on the upper and anterior aspects of the apex of the petrous bone : here the sensory fibres develop the large Gasserian ganglion beneath which runs the motor root without incorporation to join the inferior maxillary division of the nerve as this issues from the anterior convex surface of the ganglion ; the

inner aspect of the ganglion lies in immediate relation to the internal carotid artery and the posterior portion of the cavernous sinus. The ophthalmic is the smallest of the three divisions into which the trigeminus splits at the Gasserian ganglion ; it at once enters the outer wall of the cavernous sinus and ascends somewhat in its course forwards towards the sphenoidal fissure ; while in the wall of the sinus it receives communications from the cavernous plexus of the sympathetic and interchanges fibres with the third, the fourth and the sixth nerves. Before entering the orbit

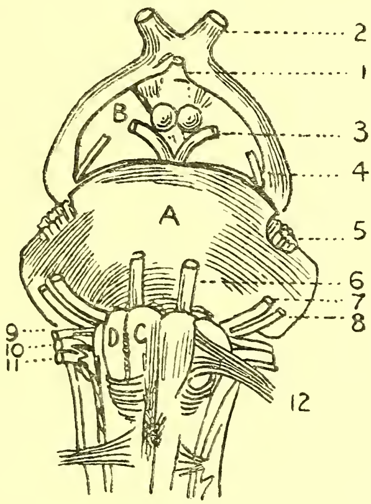



FIG. 8.

The Base of the Brain (after Hill).
1, indicates the stalk of the pituitary body; 2—12 point to the cranial nerves in order; A, pons; B, crus cerebri; C, pyramid, medulla; D, olivary body, medulla

the ophthalmic nerve has divided into the nasal, frontal and lacrimal branches and the relative positions of these nerves in the sphenoidal fissure has already been sufficiently explained.

The frontal nerve passes above both heads of the external rectus muscle and then lies on the upper surface of the levator palpebræ superioris, immediately beneath the roof of the orbit ; here it divides into the supra-trochlear

and supra-orbital nerves ; the former inclining inwards in its course forwards gives off a communication to the infra-trochlear nerve before passing above the pulley of the superior oblique muscle and turning round the internal angular process of the frontal bone to supply the skin of the forehead close to the mid-line ; it also gives twigs to

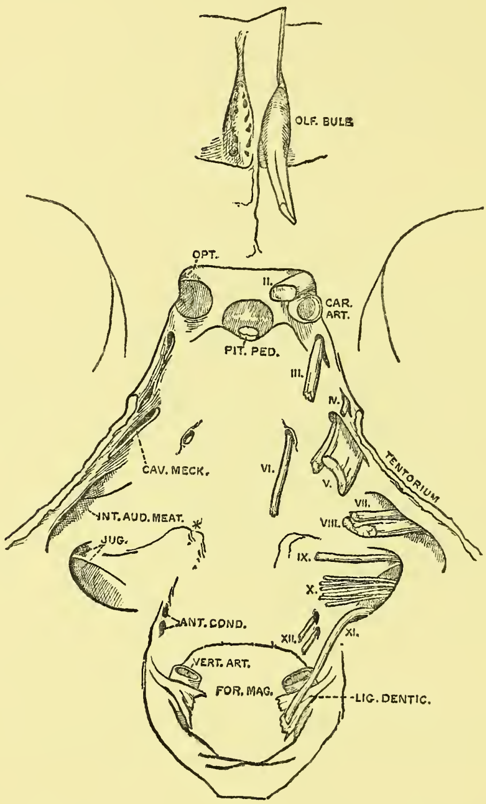



FIG. 9.

Sketch of Base of Skull, showing Entrance of the Cranial Nerves into the Dura Mater (after Thane). The tentorium has been divided close to its attachment to the upper border of the petrous bone.

the skin of the inner part of the upper lid, and the corresponding portion of the conjunctival membrane. The supra-orbital nerve is larger than the supra-trochlear ; the position in which this nerve turns round the orbital margin to gain the frontal region can easily be ascertained in the

living subject, by feeling for the supra-orbital notch at the junction of the inner third with the outer two thirds of the upper rim of the orbit ; either before or after it has gained the forehead the nerve divides into a small inner and a large outer branch ; the former perforates the muscular fibres of the frontalis and supplies sensation to the skin as far back as the coronal suture ; the latter keeps deep to the muscular belly and reaches the skin later by perforating the aponeurosis of the epicranium, but its area of distribution extends as far back as the lambdoid suture ; some twigs of the supra-orbital nerve are given to the skin of the middle portion of the upper lid, and it also supplies the mucous membrane lining the frontal air-cell by branches which pass through a small foramen generally to be seen on the skull at the bottom of the supra-orbital notch.

The lacrimal nerve passing through the sphenoidal fissure to the outer side of the frontal takes the upper border of the external rectus muscle as its guide in the orbit ; in this situation it receives a communication from the temporo-malar nerve, a branch of the second division of the fifth which has entered the orbit from the spheno-maxillary fossa through the posterior part of the spheno-maxillary fissure. The lacrimal nerve is distributed to the tear gland, and the outer part of the conjunctiva and skin of the upper lid, while a few of its terminal cutaneous filaments turn round the external angular process of the frontal bone to the most anterior part of the temporal region.

The nasal forms one of the vertical set of nerves in the sphenoidal fissure, separating in this situation the two divisions of the oculo-motor ; having passed between the two heads of the external rectus, it lies on the outer side of the optic nerve, and here gives off the long or sensory root which joins the upper part of the lenticular ganglion ; the nasal now inclines inwards to cross the optic nerve on

its upper side, and next gives off the two long ciliary nerves which join the lower set of short ciliary branches from the lenticular ganglion. Before leaving the orbit by the anterior ethmoidal canal, the nasal gives off the infra-trochlear nerve ; this branch lies under cover of the superior oblique muscle and passes beneath its pulley into the upper lid after receiving a communication from the supra-trochlear ; it is distributed to the caruncle, plica semilunaris and lacrimal sac, as well as to the skin of the upper lid and side of the nose near its root. Accompanied by the anterior ethmoidal artery, the nasal nerve gains the

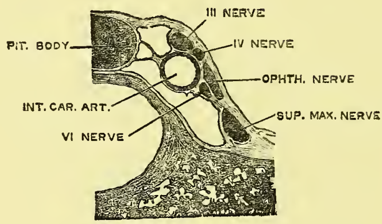



FIG. 10.

The Nerves in the Outer Wall of the Cavernous Sinus seen in Transverse Section (after Langer). From "Quain's Anatomy."

upper surface of the cribriform plate of the ethmoid bone, but almost at once passes out of the cranial cavity and into the nose by the nasal slit at the side of the crista galli ; in the nose the main trunk grooves the under aspect of the nasal bone, and finally reaches the skin at the side of the tip of the nose by emerging between the lower border of the nasal bone and the upper lateral cartilage. While in the internal orbital canal or in the nose, the nerve gives sensory branches to both sets of ethmoidal air-cells, to the sphenoidal sinus and to the upper part of the septal and lateral walls of the nasal cavity.

The second or superior maxillary division of the fifth nerve, having sprung from the anterior aspect of the Gasserian ganglion, at first runs forwards in the lowest

part of the external wall of the cavernous sinus, but very soon leaves the skull by the foramen rotundum to cross the upper part of the spheno-maxillary fossa ; here the nerve gives off its temporo-malar branch, and develops the spheno-palatine or Meckel's ganglion.

The temporo-malar nerve enters the orbit through the posterior part of the spheno-maxillary fissure and forms a communication with the lacrimal nerve — it then divides into its malar and temporal branches ; the filaments of the former tunnel the malar bone and appear as the subcutaneous malæ to supply a limited area of skin over the most prominent part of the cheek ; the temporal branch also travels in a canal in the malar bone, but in doing so takes a recurrent course so that it becomes superficial close to a small tubercle which can usually be felt on the posterior edge of the orbital process of the malar ; it is distributed to a small area of skin over the most anterior part of the temporal region. Meckel's ganglion gives off one or two small ascending twigs to the periosteum of the floor of the orbit ; its other branches of distribution to palate, nose and pharynx do not immediately concern us.

The main trunk of the second division of the trigeminus is continued from the spheno-maxillary fossa in an anterior direction as the infra-orbital nerve ; passing through the inner and posterior part of the spheno-maxillary fissure, it lies on the upper surface of the orbital plate of the superior maxilla in an open groove which is soon converted into the complete bony canal that terminates on the face as the infra-orbital foramen ; if a straight line be drawn from the supra-orbital notch to the interval between the two upper bicuspid teeth and prolonged, it passes over both the infra-orbital and the mental foramen ; the points at which the largest terminal twigs of the three divisions of the trigeminal nerve become accessible on the face are in this way easily ascertained. The infra-orbital

nerve, it is important to notice, gives the dental branches which run down in canals in the wall of the antrum of Highmore to the teeth of the upper jaw ; on the face it divides into sensory branches of distribution to the upper lip, to the side of the nose and to the conjunctiva and skin of the lower eyelid, which is thus almost entirely supplied by the second division of the fifth.

*The Facial Nerve.*—The origin of the seventh nerve, and the relation of its root to the sixth nerve, as well as the communication between its nucleus and that of the oculo-motor through the posterior longitudinal bundle, have already received sufficient notice. After its emergence from the stylo-mastoid foramen and the substance of the parotid salivary gland, it is with the temporo-facial division of the seventh that the ophthalmologist is concerned ; the temporal branches of this division ascending over the zygomatic arch are distributed to the frontalis, corrugator supercilii and orbicularis palpebrarum muscles ; they probably innervate these muscles with fibres which had their birth in the cells of the oculo-motor nucleus ; these muscular branches at their termination form communications with the supra-orbital, lacrimal and temporal sensory nerves ; the malar branches of the temporo-facial run forwards and supply the orbicularis palpebrarum in both lids, and in doing so establish communications with sensory branches from the first and the second divisions of the fifth nerve.

In view of the frequency of obstetrical paralysis of the trunk of the facial nerve, it is interesting to note that this nerve is much more superficially placed in the infant than in the adult. Owing to the tympanic ring and mastoid process of the temporal bone being undeveloped in the fœtal skull, the stylo-mastoid foramen is, at birth, almost a lateral aperture rather than an opening in the base of the cranium ; the facial nerve is in consequence much

more superficially placed on emerging from the skull, and it is probably afforded little protection by the parotid gland, seeing that at birth the function of the salivary glands is not yet established. It is easy, therefore, to realise that the seventh nerve trunk may be readily damaged by the forceps' blade in cases of instrumental delivery, and after birth the child will temporarily suffer from paralysis of all parts of the orbicularis palpebrarum muscle on the side injured.

*The Olfactory Sense.*—The lateral and mesial roots of the olfactory tract helping to bound in front the anterior perforated spot have already been alluded to. The mesial root fibres can be traced to the anterior end of the limbic lobe, *i.e.*, the convolution which is seen on the mesial aspect of the hemisphere to immediately embrace the corpus callosum ; commissural fibres are found to connect the mesial roots of the two olfactory tracts : in man, the lateral root fades off after forming the antero-lateral boundary of the anterior perforated space (fig. 1), but in animals possessed of a well-developed sense of smell this root is traceable to the hook of the uncinate convolution, *i.e.*, the posterior end of the same limbic lobe. The olfactory tract extends forwards in the antero-posterior sulcus on the under aspect of the frontal lobe and enlarges into the bulb, which lies on the cribriform plate of the ethmoid bone ; the olfactory nerves, about twenty in number on each side, spring from the under aspect of the bulb and pass in two sets through the cribriform foramina to be distributed over the upper part of the septal and lateral walls of the nose respectively ; the outer set is the larger group ; its filaments do not reach lower than the superior turbinate bone.

# CHAPTER IV.

## The Cervical Sympathetic and Lenticular Ganglion.

The spinal fibres of this system, which controls the involuntary muscular tissue in the lids, eyeballs and orbits, leave the cord by the first four or five dorsal nerve roots to join the corresponding thoracic ganglia, ascend through the lower and middle cervical ganglia, and terminate in the large superior cervical sympathetic ganglia ; here the only relay in the ocular and orbital sympathetic fibres is established; here the immediate vaso-constrictor, pupillo-dilator and other fibres spring from the cells of the ganglion ; they are conveyed on the internal carotid artery to the Gasserian ganglion, to form the carotid plexus at the apex of the petrous bone and the cavernous plexus on the same artery where it is enclosed in the venous sinus. The filaments of communication between the first plexus and the sixth nerve and those between the second plexus and the third, fourth and ophthalmic division of the fifth nerves have been already referred to; a continuation of the cavernous plexus is to be traced on the ophthalmic artery, and its fibrils are conveyed to the ultimate branches of the artery ; a plexus will therefore be found on the central artery of the retina and cases of arterial spasm of the retina, may thus be anatomically explained; variations in calibre of the arteries of the vascular tunic of the eyeball are similarly rendered intelligible by the fact that the cavernous plexus gives the sympathetic root to the ciliary ganglion, which root, by the way, is often found to be incorporated with

the long sensory root from the nasal nerve before the ganglion is reached. Sympathetic fibres are also distributed to the delicate sheet of involuntary muscle which bridges across the spheno-maxillary fissure, and to the unstriped muscle fibres which help to attach the tarsal plates of both lids to the orbital margin.

In view of the facts that paralysis of the cervical sympathetic nerve is diagnosed mainly from the ocular symptoms to which it gives rise and that excision of the superior cervical ganglion has recently been advocated and practised in the treatment of some cases of glaucoma, it seems necessary to add a few words as to the coarse anatomy of this portion of the sympathetic trunk. The chain lies on the front of the roots of the transverse processes of the cervical vertebræ, upon the rectus capitis anticus major muscle above and the oblique portion of the longus colli muscle at the root of the neck ; it is imbedded in the posterior wall of the carotid sheath, by which it is separated from the structures which that sheath envelopes, viz., the internal carotid artery, the internal jugular vein and the vagus nerve above the level of the upper border of the thyroid cartilage, and the common carotid trunk with the same vein and nerve below that level. The superior cervical ganglion lies opposite the second and third vertebræ, is nearly an inch in length and fusiform in shape ; it is connected by rami communicantes with the upper four cervical nerves and reaches nearly to the base of the skull ; it gives branches to the pharyngeal, plexus, and the ascending branch on the internal carotid artery which eventually forms the carotid and cavernous plexuses and probably also conveys fibres to the Gasserian ganglion ; it establishes communications with the ganglia of the vagus and glosso-pharyngeal nerves and with the trunk of the hypoglossal, and distributes a descending branch, the upper cardiac nerve. The middle cervical ganglion is found

opposite the sixth cervical vertebra, a level which corresponds with the cricoid cartilage; its rami unite it to the fifth and sixth spinal nerves; it gives off a middle cardiac branch and thyroid twigs which accompany the inferior thyroid artery. The inferior cervical ganglion is situated on the anterior aspect of the articulation between the head of the first rib and the body of the first dorsal vertebra; in the same line on the lower costo-central articulations the thoracic sympathetic ganglia are placed. The cord, where it connects the middle with the inferior cervical ganglion, takes a direction somewhat outwards as well as downwards and in doing so passes behind the vertically ascending vertebral branch of the subclavian artery; the vertebral, it will be remembered, runs upwards in the intermuscular depression between the longus colli and scalenus anticus to gain the foramen in the root of the transverse process of the sixth cervical vertebra; any success which could be claimed in the treatment of epilepsy by Alexander's operation of ligature of the vertebral in this space, was attributed by some to the interference with the sympathetic which the operative procedure involved; the recollection of this contention will help to impress on the mind the intimate relationship which here exists between the cervical sympathetic and the vertebral artery. The inferior cervical ganglion receives rami communicantes from the seventh and eighth spinal nerves and gives off the inferior cervical cardiac nerves and filaments which run on the vertebral artery. A few fibres pass from the middle to the inferior cervical ganglion, and sometimes to the first thoracic ganglion which is almost fused with the inferior ganglion, by a circuitous route in front of the first stage of the subclavian artery; these looping fibres form the ansa Vieussenii; the rami communicantes to the lowest cervical ganglion and the upper thoracic ganglia are very short.

The pupillo-dilator fibres reach the sympathetic system by the roots of the first, second and third dorsal nerves; Langley has traced the motor fibres to the involuntary muscles of the orbit, nictitating membrane and eyelids, from as many as the first five dorsal nerves.

It can now easily be appreciated how thoracic aneurisms or mediastinal growths may give rise to symptoms of cervical sympathetic nerve paralysis; at the root of the neck aneurisms on the earliest stages of the branches of the aortic arch may implicate the sympathetic chain, its ganglia, or their roots; higher in the neck carotid aneurisms, glandular masses or thyroid tumours may press upon the sympathetic cord.

*The Ciliary or Lenticular Ganglion* is a small square body flattened laterally, and occupying a position in the orbit between the external rectus muscle and the optic nerve in close proximity to the ophthalmic artery. Each of its sides measures about 2 mm.; its posterior border receives the short stout motor root from the nerve to the inferior oblique, which passes to its muscle immediately below the ganglion; the twigs constituting its sympathetic root come from the cavernous plexus; they and the long sensory root from the nasal nerve join the upper part of the posterior border of the ganglion. Its branches of distribution come off from its anterior edge and arrange themselves as an upper and a lower group in reference to the optic nerve; these constitute the short ciliary nerves, about twenty in number, which perforate the sclerotic coat of the eyeball close around the porus opticus; the lower set of short ciliary nerves is joined by one or two long ciliaries derived directly from the nasal. The ciliary nerves for the most part run in the loose tissue between the sclerotic and choroid coats to reach the ciliary region, iris and cornea; motor fibres are also supplied by them to the intra-ocular muscles. The sensory fibres of the eyeball are seen to

be all derived either directly or indirectly from the nasal nerve, and there is in consequence an intimate physiological relation between the skin and mucous membrane areas to which this nerve is distributed and the sensitive anterior portions of the globe.

# CHAPTER V.

## Cutaneous Nerve Areas of Head and Face. Cerebral Topography.

*Cutaneous Nerve Areas of the Head and Face.*—Fig. 11 indicates the distribution of sensory nerves to the skin of the scalp and face, and but little comment is needed to explain it. In regard to the infra-trochlear nerve a want of

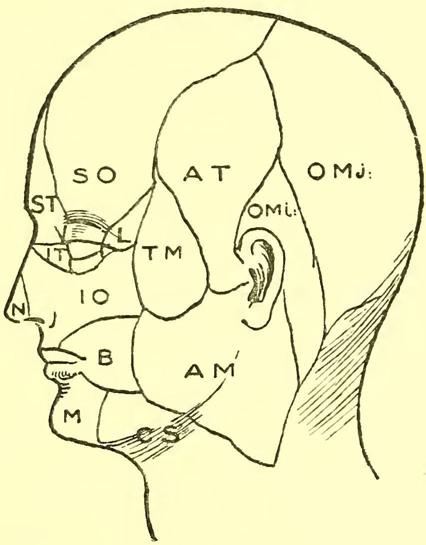



Fig. 11.

Cutaneous Distribution of Sensory Nerves (after Macalister).

ST, supra-trochlear; IT, infra-trochlear; N, nasal; L, lacrimal; SO, supra-orbital; TM, temporo-malar IO, infra-orbital; M, mental; B, buccal; AT, auriculo-temporal; AM, great auricular; CS, superficial cervical; OMi, small occipital; OMj, great occipital.

definition in the diagram is perhaps inclined to accentuate an easily made error; this nerve, passing out of the orbit immediately below the pulley of the superior oblique

tendon, emerges from under the supra-orbital margin, and supplies skin and conjunctiva mainly of the upper and only to a small extent of the lower lid ; it does, however, send a few filaments to the lower lid and is responsible for the sensory supply of the lacrimal sac. The nasal nerve supplies the side of the cartilaginous portion of the nose ; in the orbital portion of its course the same nerve has supplied the long ciliary nerves and the sensory filaments to the lenticular ganglion which are eventually distributed to the globe and corneal epithelium ; the afferent path of the reflex act of winking therefore varies according to whether the tactile stimulus which provokes it is applied to the cornea or to the conjunctiva.

The sensation of the lower lid, and of the skin of the face below and to the outer side of the orbit, is seen to be supplied by the second division of the fifth nerve.

The skin and mucous membrane of that part of the cheek which is formed by the buccinator muscle are supplied with sensation by the buccal branch of the third division of the fifth nerve. The auriculo-temporal and mental nerves are the other sensory branches of the third division of the trigeminus which have a cutaneous distribution.

The superficial cervical, great auricular and small occipital nerves form the ascending set of branches of the superficial cervical plexus and are derived from the anterior divisions of the second and third spinal nerves.

The great occipital represents the internal branch of the posterior division of the second cervical nerve.

The muscles of expression all receive their motor supply through the facial nerve, which is responsible also for the innervation of the bellies of the occipito-frontalis (with certain qualifications already specified), and the extrinsic muscles of the pinna. The muscles of mastication include the masseter, temporal and pterygoid

muscles, and are supplied by the motor division of the third portion of the fifth nerve.

*Cerebral Topography.*—Some knowledge of the cranial topography of the various centres and portions of the brain with which the ophthalmologist is concerned cannot fail to be of interest, and in the elucidation of traumatic lesions may be of practical utility.

The method of Horsley, while suitable for the general surgeon, will not avail for the ophthalmologist ; the locali-

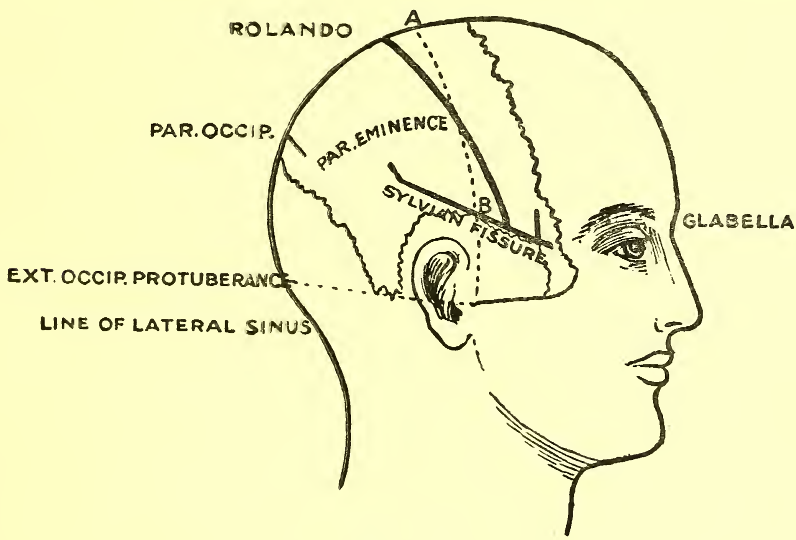



FIG. 12.

A, mid-sagittal point ; B, squamosal point. Modified from Treves.

sation of cerebral centres by their known general relationship to cranial sutures exposed by turning down a large flap of the scalp is obviously only of value in the operating theatre. Hare's method of localisation involves the possession of a special angle-rule with which to take measurements, while the plans devised by Reid and by Anderson and Makins involve rather complicated reckonings.

I do not propose to describe here in detail any of these methods. It will be sufficient to recall a few general facts. The upper end of the fissure of Rolando may be taken to

lie at a point about three-eighths of an inch behind the mid-point of a sagittal line, measured from the glabella to the occipital protuberance ; a point at the junction of the middle and lower thirds of a line drawn from the mid-sagittal point to a point in front of the tragus of the pinna on a level with the upper border of the external auditory meatus has been called the " squamosal point " by Anderson and Makins ; the line they call the " frontal line," and find it is crossed obliquely by the Rolandic fissure in such a way that the lower end of the fissure lies three-eighths of an inch in front of the squamosal point. A line drawn from the external angular process of the frontal bone through the squamosal point and prolonged backwards to turn slightly upwards behind the parietal eminence, gives a rough guide to the main limb of the Sylvian fissure ; the fissure commences one and a quarter inches behind the external angular process, and the frontal line divides the horizontal limb of the Sylvian fissure into two equal parts ; the first three-quarters of an inch of the tracing indicates the main Sylvian fissure ; the remainder is its horizontal limb ; the ascending limb runs vertically upwards for about an inch at the junction of the stem and the horizontal limb.

*Note.*—For the purposes of the above measurements the glabella and the external angular process should be considered to lie at the level of the upper margin of the orbit.

It will be remembered that the angular gyrus surrounds the up-turned end of the parallel fissure, which lies immediately behind the corresponding termination of the horizontal limb of the Sylvian fissure, which itself is similarly surrounded by the supra-marginal convolution ; the latter convolution Prof. Turner considers to be sufficiently indicated by the parietal eminence. The positions of the motor cortex and frontal convolutions

can be appreciated now that the fissures of Rolando and Sylvius have been delineated.

A line drawn from the external occipital eminence to the top of the external auditory meatus will indicate the position of the attached margin of the tentorium cerebelli and the course of the lateral sinus : the level of the occipital pole of the hemisphere is in this way realised. At a point rather nearer to the mid-sagittal point than to the external occipital protuberance, *i.e.*, at a point that corresponds very fairly with the lambda, the parieto-occipital fissure is to be marked upon the skull ; the limits of the occipital lobe are now indicated for us. The stem of the calcarine fissure usually takes a downward course at its posterior end, so that it cuts the margin of the hemisphere as a rule very little above the occipital pole ; sections of the brain hardened *in situ* show the posterior end of the calcarine fissure to make an angle of about forty-five degrees with the horizontal ; the calcarine and internal parieto-occipital fissures meet at about a right angle ; the central part of the tentorium is greatly domed by the hind brain and cerebellum lying beneath it.

The corpus striatum and optic thalamus are covered superficially by the gyri of the central lobe or Island of Reil ; this lobe is buried in the anterior half of the fissure of Sylvius ; the two large basal ganglia have their limits defined with fair accuracy therefore by the anterior half of the Sylvian fissure ; a coronal section of the skull through the squamosal points would be found to pass through the corpora quadrigemina, the iter a tertio ad quartum ventriculum, and the pulvinar tubercles of the optic thalami.

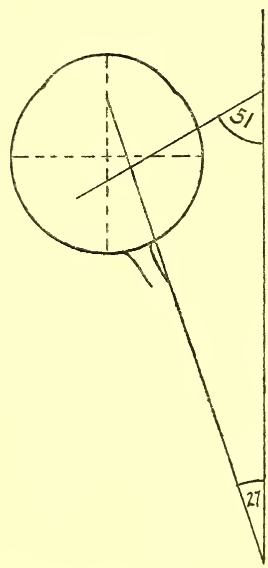
# CHAPTER VI.

## Ocular Movements and Muscles. Paralytic Squint and Concomitant Strabismus. Tenon's Capsule.

In considering the movements of the eyes produced by the extra-ocular muscles and the defects in movement which arise from the paresis of them, much confusion is frequently caused by the terms employed to denote the various movements. The word "rotation" is responsible for much of this unnecessary ambiguity; we read of rotation in and rotation out, rotation up and rotation down; for such terms in this chapter adduction, abduction, elevation and depression will be respectively substituted; in this way the word rotation can be avoided in referring to the movements of the eyeball, which take place about the vertical and the transverse axes; to the wheel-like movement which can, potentially at least, take place about the antero-posterior axis the term rotation seems especially applicable; this movement can obviously be contemplated as taking place in two directions; "inward rotation" will be employed to denote the wheel-like movement which would result in the globe rolling towards the nose, were it free to travel, and "outward rotation" to describe the movement which would result in the globe rolling away from the nose.

Of the straight muscles the lateral recti can produce movement only on the vertical axis; the internal rectus is a pure adductor, the external rectus is a pure abductor.

When, however, we consider the superior and inferior rectus muscles, we find that they pass from their origins at the optic foramen in a direction forwards and outwards to reach their insertions a few millimetres behind the sclero-corneal junction; the angle which each makes is about 27° with the antero-posterior axis of the eyeball. If, therefore, the globe be abducted 27° from its primary position, the superior rectus will, passing on the upper surface of the eyeball, be a pure elevator, while the inferior rectus, in the same position of the eye, will be a pure depressor. In the primary position of the globe, however, the superior rectus will tend to produce a wheel-like movement inwards, inward rotation, while the inferior rectus passing beneath the globe will be an external rotator; their power as rotators is obviously increased when the eye is adducted. In the vertical movements which they produce and in their rotatory powers, the superior and inferior recti muscles are seen to be antagonistic, and this will be the case whether the eyeball be in the primary position or in a position of abduction or adduction; by acting together, however, they will, unless the globe is abducted at least 27° from the primary position, serve as supplementary adductors to the pure adductor, the internal rectus; their action in this respect may perhaps be more readily realised if we compare it to the combined action of the flexor carpi ulnaris with the extensor carpi ulnaris in producing adduction or ulnar flexion of the hand upon the forearm.



The action of these muscles may then be tabulated thus :—

| | | | |
|---|---|---|---|
| *Internal rectus* — | | — Adductor — | |
| *Superior rectus* — | Elevator | — Adductor — | Internal rotator. |
| *Inferior rectus* — | Depressor | — Adductor — | External rotator. |

In considering the action of the superior and inferior oblique muscles, we have to recollect that the latter in its whole length and the tendon of the former from its pulley run backwards and outwards, to be inserted on the postero-external quadrant of the globe near to its posterior pole, and that the angle which each muscle in approaching its insertion makes with the antero-posterior axis is about 51°. Remembering then that the superior oblique tendon descends from the roof of the orbit and that the inferior oblique ascends from the floor, it is easy to see that the actions may be briefly expressed as :—

| | | | |
|---|---|---|---|
| *External rectus* — | | — Abductor — | |
| *Superior oblique* — | Depressor | — Abductor — | Internal rotator. |
| *Inferior oblique* — | Elevator | — Abductor — | External rotator. |

If the globe be adducted 51° the superior oblique becomes a pure depressor and the inferior oblique a pure elevator, while their rotatory powers increase and their vertical powers diminish, as a position of abduction is assumed ; each of them contributes a quota to abduction, but in all other respects the two obliques are in opposition. In looking vertically upwards from the primary position we use the superior rectus and the inferior oblique together, and it will be observed from the above tables that the tendency of the one muscle to produce at the same time undesired movements of adduction and internal rotation, is neutralised by the simultaneous tendency of its associate to produce movements of abduction and external rotation.

Similarly to produce a movement of pure depression from the primary position the inferior rectus and the superior oblique act together.

To look upwards with the eye adducted we shall rely chiefly on the inferior oblique, now a more or less pure elevator according to the angle of adduction maintained, the superior rectus being, when the eye is thus lateralised, capable of producing mainly rotatory movement ; similarly the superior oblique will be the chief depressor of the eye in the appropriate adducted position, the inferior rectus being now at a disadvantage in contributing to this movement. In the appropriate abducted position we shall look upwards mainly by using the superior rectus, now a pure elevator, and downwards mainly by using the inferior rectus, now a pure depressor, the obliques being now responsible for the rotatory movements and giving but little help to produce the vertical movements. It is interesting here to note that in the extremely important and delicate movements of convergence of the optic axes necessary for accurate fixation of a near object, we shall use in each eye three muscles, viz., the superior, inferior and internal recti, each supplied by the third nerve, which also carries the impulses to the ciliary muscles and sphincter pupillæ in action at the same time ; this movement will of course be regulated by the three abducting muscles, as the movement effected by any group of muscles in the body is invariably controlled by the antagonistic group. The movement of restitution to the primary position of parallelism will be produced by a preponderance of the three abducting muscles, the external rectus, the superior oblique and the inferior oblique, supplied by the sixth, fourth and third nerves respectively. It is often stated and printed that we lateralise the eyes by using the internal and external recti, but that the vertical and oblique movements are more complicated in their production and are affected by com-

binations of the extra-ocular muscles—even the roughest of our movements is never produced by the isolated contraction of a single straight muscle ; it is well to enter a protest against such careless statements repeatedly made, which, instead of simplifying, only confuse our consideration of the very delicate and exact movements of the eyeballs.

The angles at which the muscles approach the globe seem to be arranged so that when from the position of the eyeball the superior rectus is reduced to a pure elevator the inferior oblique still helps it to raise the cornea, though feebly, and when the superior oblique is a pure depressor, the inferior rectus, though in this position mainly a rotator, still retains some power of depression. There is no position of the eyeball in which the superior rectus being a pure elevator the inferior oblique is reduced to a pure rotator, &c.

Landolt finds the eye to be capable of an equal excursion in all directions, amounting to about 47° from the primary position.

The determination of the muscle at fault in a paralytic squint is in some cases a very simple matter ; it is in the slighter cases of paresis, where the muscle implicated has to be deduced from the nature of the resulting diplopia, that difficulty is experienced. To reduce this difficulty to a minimum a clear perception of the direction and action of the various muscles in health must be maintained ; an endeavour has been made above to bring this concisely before the reader in a form in which it can be retained and will be found most practically useful ; one or two further facts as to the double images must also be borne in mind, viz. :—

When the deviation of the visual axes from the primary position of parallelism is such that these axes become crossed anteriorly, the images are uncrossed, or, as it is commonly expressed, the diplopia is homonymous.

When the axes deviate from parallelism so as to become divergent the images are crossed; crossed diplopia exists when the axes are uncrossed.

When one eye is directed at the object fixed and the visual axis of the other is so misdirected as to pass above the object, the image seen with the elevated eye appears lower than the one seen with the fixing eye; and conversely when one eye is depressed its image appears higher than that of the fixing eye.

When the eye is required to be turned into such a position as the affected muscle especially promotes when in health, the angle of deviation between the axes will be increased, with a corresponding increase in the interval between the two images which the patient sees.

Practically a candle flame is the object towards which the patient with diplopia is asked to direct his eyes and his attention, preferably in a dark room at not less than two metres distance. A bright red glass is placed in a trial-frame in front of one eye, say the left, in order to render the images conspicuously different to the patient, and to enable him to speak with discrimination of what he sees to the examiner. Let us imagine that his statement is that he sees two candle flames placed side by side, the red flame appearing to the left of the white flame; the images then are uncrossed, therefore the axes are crossed; an abducting muscle in one or other eye is affected; a pure abductor, because had it been one of the oblique muscles a vertical as well as a lateral displacement would have been observed in the false image, and probably also some leaning of the image would have been described, seeing that the obliques move the eyes vertically as well as laterally and potentially produce rotation; one of the external recti then is at fault; the candle is now held more to the patient's left hand side and he is instructed to turn the eyes towards it without moving the head; he still sees the red flame to the left of

the white flame, the red one being now separated from the white one by a greater interval than when the candle was straight in front of him ; the axes of the eyes are therefore more crossed now than before ; this can only be due to paresis of the left external rectus ; if he follows the candle to the right hand side, the interval diminishes and the images may fuse into one, as would be expected, the paretic muscle, the left external rectus, being now out of court as far as producing active lateralisation of the eyes is concerned. Again, the red glass in front of the left eye ; two candle flames seen, side by side, one no higher than the other, and neither leaning, but the red flame to the right of the white flame ; the images then are crossed ; the visual axes are therefore uncrossed ; the squint is a divergent one due to weakness of the right or the left internal rectus ; the candle is carried to the patient's right hand side and one image only is seen ; the left internal rectus being now in active use and the eyes fixing correctly, obviously it is not this muscle which is at fault ; carry the candle to the left and the crossed images reappear separated by a greater interval than ever ; the right is now the internal rectus which should be in active contraction and is obviously unable adequately to perform its duty, or, in other words, is the paretic muscle.

Again, the red glass is placed in front of the left eye. The red candle appears below the white candle ; the left eye is therefore directed higher than the right ; this clearly may be due to weakness of a depressor of the left eye or of an elevator of the right. Let the patient, employing movements of the eyes only, follow the candle flame when it is lowered into the inferior part of the field of fixation ; the red candle he now finds to appear lower than the white one by an increased interval ; in following the candle into the upper part of the fixation field the vertical displacement between the images diminishes ; elevation of both eyes is therefore well performed, while depression of the left is

proved to be defective. The left inferior rectus or the left superior oblique must therefore be at fault. The left superior oblique is a pure depressor when the left eye is adducted, but has little depressing power when the left eye is abducted, the inferior rectus being the chief depressor muscle in this position of the eye ; if then, continuing our testing, the vertical interval between the two candle flames is greater when the eyes are turned down and to the right, than when they are turned down and to the left, the left superior oblique is the muscle at fault ; if the converse is found to be the case the patient is the subject of paresis of the left inferior rectus. A similar method of testing and reasoning if an elevating muscle is found to be at fault will prove whether the inferior oblique or the superior rectus is responsible.

It is necessary also to recognise the fact that when the elevating or depressing muscles are at fault, there will be some lateral as well as vertical displacement of the images, as each of these muscles is either an accessory abductor or an accessory adductor : thus, the superior oblique is an abductor as well as a depressor and when it is paretic the diplopia will be homonymous, in some parts of the fixation field, as well as vertical; when the inferior rectus, a supplementary adductor as well as a depressor, is at fault, the diplopia will be crossed as well as vertical. Accurate observation of these facts will give confirmatory evidence as to which depressor or elevator is involved.

An ophthalmic surgeon who has frequent opportunities of employing the above tests can also often deduce accurate results from the leaning of the images, but into this it would hardly be profitable to enter here ; the exposition would only render the subject more complicated and the deductions are not always reliable, as on these points patients can readily mislead the examiner with faulty observations or methods of expression.

As a practical point in employing the candle test for diplopia, it is found better to keep the flame in a fixed position about two metres from the patient's eyes, and to bring the ocular muscles into play as required by movements of his head ; *e.g.*, the head is thrown back when the depressors are being tested, and the chin dropped on the sternum when the elevators are to be examined ; rotation of the head will enable us to test either pair of lateralising muscles ; the patient is of course told to keep his eyes directed towards the candle flame while his head is placed in the required position.

*The Capsule of Tenon, or Bulbar Fascia.*—The capsule of Tenon is usually described as a fairly definite fibrous sheet enveloping the posterior four-fifths of the eyeball ; posteriorly becoming continuous with the dura-matral sheath of the optic nerve and anteriorly blending with the ocular conjunctiva and becoming with it attached to the sclera at the limbus. This anterior part of Tenon's capsule can as a rule be easily demonstrated in growing subjects as a second glistening white membrane beneath the ocular conjunctiva ; in the later years of life it appears to undergo a certain amount of atrophy and it is difficult to exhibit it as a membrane independent of the conjunctiva. Between the capsule and the surface of the sclerotic pass delicate trabeculæ, amid the interstices of which lymph circulates. All the extra-ocular muscles have to perforate this capsule to gain their tendinous insertions into the sclera, and that lip of every aperture which is the nearer to the origin of the muscle is stiffened and rendered more rigid so as to form a sort of pulley-bar around which the tendon bends and plays. A reflected sheath is sent backwards from the capsule of Tenon on to every muscle ; the sheath eventually blends with the perimysium, except in the case of the superior oblique, where the sheath, in this case a particularly strong one, does not reach

the fleshy fibres but terminates at the trochlea of the tendon.

It is by means of these reflected sheaths that the extra-ocular muscles maintain their hold upon Tenon's capsule

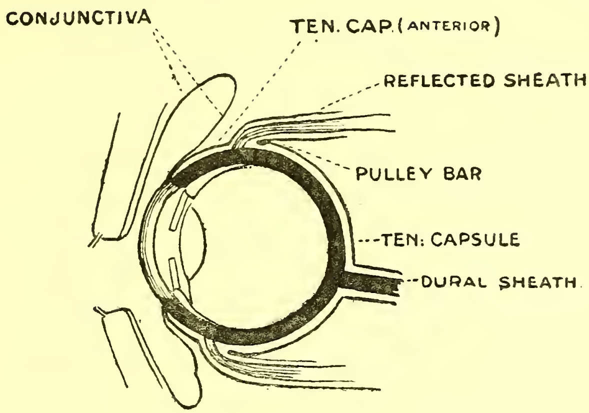



FIG. 13.

Diagram to show the main portions of Tenon's Capsule. The secondary reflections from the muscle sheaths are omitted.

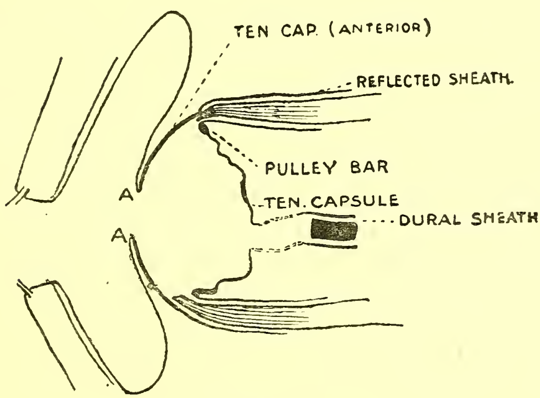



FIG. 14.

Diagram to show the condition of Tenon's Capsule after excision of the eyeball. By the anterior portion of the capsule, which still remains blended with the ocular conjunctiva, the recti muscles retain an attachment to the socket which will carry the artificial eye. The cut margin of conjunctiva at A A heals and completes the posterior wall of the socket.

after the operation of excision of the globe, or after tenotomy; the importance of dividing the tendons close to their insertions into the sclerotic in these operations will be realised; after a well-performed excision the anterior

extension of Tenon's capsule still remains intimately adherent to the ocular conjunctiva and so enables the recti muscles to exercise their action upon the conjunctival socket, and thus to produce the movements of the artificial eye. A reference to figs. 13 and 14 will make this clear; in fig. 14, the cut edges A A of the ocular conjunctiva unite and so complete the posterior wall of the socket in which the artificial eye is worn; the same fig. (14) shows the potential cavity formed by Tenon's capsule when the globe has been excised; into this cavity some surgeons are in the habit of introducing the artificial vitreous which is placed in the eviscerated sclerotic in Mules' operation.

The reflected sheath on the external rectus is attached to the outer wall of the orbit by a band of fibres passing to the malar bone in conjunction with the external tarsal ligament of the eyelids; this band is known as the external check ligament. A similar internal check ligament runs from the sheath of the internal rectus to be attached to the vertical crest of the lacrimal bone in association with that smaller lamina of the internal tarsal ligament which passes behind the lacrimal sac. A corresponding slip from the capsule sheath of the superior rectus joins the tendon of the levator palpebræ superioris and thus enables the rectus to slightly raise the lid at the same time that it elevates the cornea. The prolongation from the inferior rectus sheath passes directly to the lower edge of the tarsal plate of the lower lid with a similar object. The check ligaments of the lateral recti are considered to limit over-action of these muscles and at the same time to assist the pulley-bars in preventing the muscles from exercising deforming pressure upon the globe when they contract.

The anterior inferior part of the main capsule of Tenon is strengthened into a band which at its extremities is attached to bone with the lateral check ligaments; this band therefore runs as a sling beneath the forepart of the

globe and holds it in position ; it is known as the suspensory ligament of Lockwood and the importance of its preservation in the operation of excision of the superior maxilla is insisted upon so that the position of the eyeball may remain undisturbed.

The capsule of Tenon, so arranged, is usually described as forming a cup or socket in which the globe, in its various movements, plays as a ball, the lymph between the capsule and the sclera acting as a lubricating synovial fluid. Such an interpretation of its function appears to me untenable. I entirely fail to see how the eyeball can roll in such a socket when it is remembered that the capsule is continuous posteriorly with the fibrous sheath of the optic nerve and anteriorly is attached with the conjunctiva to the eyeball at the sclero-corneal junction ; surely the optic nerve cannot play up and down in its dura mater sheath like a piston in its cylinder ; the relation of the capsule to the extra-ocular muscles seems also incompatible with such a theory.

Schwalbe regards the bulbar fascia, as above described, to represent only the parietal layer of a closed serous sac ; the visceral layer he describes as a lamina of extreme tenuity blending with the surface of the sclerotic ; he finds the sac to be lined everywhere with endothelial cells which clothe also the delicate trabeculæ which, in his view, cross between the parietal and visceral portions. This view of the construction of the capsule of Tenon renders it easier to conceive of the globe, closely invested with the visceral layer, revolving within the stouter parietal portion, but I do not think meets all the objections, particularly that with regard to the behaviour of the optic nerve. I regard the globe and capsule as moving harmoniously together upon the retro-ocular tissues, *i.e.*, the fat packing the orbit ; this, in the living subject, will be in a semi-fluid condition and it is easy to conceive of such a movement

taking place; the sinuous course of the optic nerve seems designed with this express object; only by such an arrangement I believe could the retinal and choroidal circulations go on unimpeded in all the different positions into which the eyeball can be turned.

*The Extra-Ocular Muscles.* — Fig. 15 gives an idea, sufficient for our purpose, of the origin of the recti muscles by a fibrous band of horseshoe shape; the upper limb of this band passing above the optic foramen is known as the

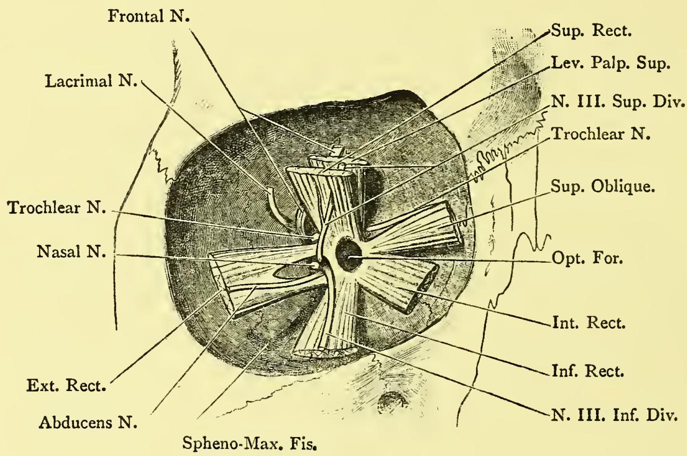



FIG. 15.
To show the origin of the ocular muscles and their relation to the nerves entering the orbit at the sphenoidal fissure (after Cunningham).

superior common ligament of Lockwood; the lower limb is know as the ligament of Zinn; the two limbs join to form the toe of the horseshoe on the inner side of the optic foramen and give origin conjointly to the internal rectus muscle; the outer end of Lockwood's ligament terminates above and to the outer side of the optic foramen, while the ligament of Zinn crosses the lower part of the sphenoidal fissure to be attached to a tubercle on the outer lip of the fissure; the external rectus springs from the unclosed ends of the horseshoe by two heads which form a fibrous arch through which certain of the nerves, the vertical set, are seen to pass as they enter the orbit and

come into relationship with the optic nerve; the early relation of the fourth, frontal and lacrimal nerves, the horizontal set, to the external rectus, is also indicated in the diagram.

In view of operative procedures on the recti muscles it is necessary to remember that the internal rectus is the muscle whose insertion approaches nearest to the sclero-corneal junction; the insertions of the other recti lie in a gradually receding spiral traced round the globe so as to pass below, then ascending on its outer side and finally passing inwards across its upper side; the internal rectus is found to be inserted into the sclerotic about three lines from the corneal edge, while the superior rectus, the most posterior of the four as regards their attachment, is one line farther removed. The obliques, it has already been stated, insert near to the optic nerve, close together on the postero-external quadrant of the eyeball; in myopic eyes the line of the superior oblique attachment is found to run almost antero-posteriorly and to lie entirely in this quadrant; in hypermetropic and emmetropic eyeballs its line of attachment is more obliquely directed, so that its posterior and inner limit transgresses the vertical mid-plane and enters upon the postero-internal quadrant to a very slight extent. The superior oblique arises from the body of the sphenoid bone just in front of the inner part of the optic foramen; its fleshy belly runs forwards at the junction of the inner and superior walls of the orbit; its pulley can usually be felt during life immediately behind the internal angular process where it is attached in a small dimple in the orbital plate of the frontal bone. Its reflected tendon runs obliquely backwards and outwards above the eyeball, passing between the superior rectus and the globe to reach its insertion. The fourth nerve supplies the superior oblique and enters it on its orbital aspect a very short distance in front of the optic foramen. The inferior

oblique muscle arises from a depression in the orbital plate of the superior maxilla immediately external to the groove for the lacrimal sac ; the muscle takes a direction parallel to that of the reflected tendon of the superior oblique ; it crosses the line of the inferior rectus, which intervenes between it and the under aspect of the globe, and its insertion is very slightly nearer to the optic nerve than is that of the superior oblique.

The following article was published by the author in the *Royal London Ophthalmic Hospital Reports*, vol. xiv., part 3, and is reprinted from that source :—

" *Concomitant Strabismus : the Accessory Adductors and Abductors.*

" In speaking of the movements of the eyes we are constantly meeting with the statement that pure lateral movements of adduction and abduction are effected by the isolated action of the internal rectus and external rectus muscles respectively. This is a statement to which I think few anatomists and physiologists agree, and which few ophthalmologists on consideration really, I believe, would accept. It is in the first place contrary to our knowledge of the behaviour of muscles elsewhere in the body ; in the movement, for example, of elevation of the hyoid bone and larynx, muscles such as the two digastrics and stylohyoids are provided to do the work which at first sight a single vertical muscle could effect, seeing that no lateral deviation of these mid-line structures of the neck is required or allowed ; the movement restoring the hyoid bone and larynx to their positions of rest is carried out by the muscles of depression, the sternohyoids, and sterno-thyroids, neither of which runs in the vertical direction, and by the digastric muscles, the omohyoids. We learn that these arrangements secure steadiness of action, and accept it as a satisfactory explanation, because it accords

with our general examination and experience of muscles elsewhere in the body. Do we then really believe that Nature has been so remiss as to provide a single straight muscle to act alone in effecting a movement where delicacy, accuracy, and steadiness are perhaps more essential than in any other of which we are capable? Still the fallacy is perpetuated in text-books, and it seems to me, leads us into greater difficulties. We learn that in uncorrected hypermetropia the inability to dissociate the action of the converging internal recti from the action of the ciliary muscles and pupillary sphincters results, especially when the correcting influence afforded by binocular vision is from any cause reduced, in preponderance of the internal recti and convergent strabismus; when, however, in high myopia the incentive to convergence is that in order to get clear images the patient holds objects close to his eyes, we accept the statement that the internal recti refuse to respond to this stimulus, or if they do so for a time and have presumably, in consequence of much use, hypertrophied, in time of tribulation they fall away, and declining further to make the efforts required, divergent strabismus is the result. Insufficiency of the adductors to maintain convergence in times when the general health is enfeebled we may believe, but insufficiency of these hypertrophied adducting muscles to maintain the parallelism of the primary position against abducting external recti which, like the myopes ciliary muscle are probably atrophic from diminished use, is hard to accept. It comes to this, that in over-use from one cause the internal recti hypertrophy and give rise to convergence, while in over-use from another cause they perversely become enfeebled and allow divergence, when in either case binocular vision is impaired.

"We are led into these difficulties from regarding the lateral recti as the sole agents in providing pure lateral

movement of the eyes. There is, to my mind, no doubt whatever that the superior rectus and inferior rectus passing from their origins forwards and outwards to their insertions in front of the centre for lateral movement of adduction, can and do contribute to this movement, whether it be effected for convergence or in association with abduction of the fellow eye. In acting together the tendency of the superior rectus to elevate the cornea is neutralised by the tendency of the inferior rectus to depress it ; the rotation of the globe on the antero-posterior axis which the superior rectus tends to provide (wheel-like movement towards the nose) is counteracted by the opposite rotation on the same axis attempted by the inferior rectus.

| | | | |
|---|---|---|---|
| *Superior rectus* . . | Elevator. | Internal rotator . | Adductor. |
| *Inferior rectus* . . | Depressor. | External rotator . | Adductor. |

"The quota of adduction contributed by each remains, when both act together, to supplement that of the pure adductor, the internal rectus. Here then we have three good muscles, all innervated like the ciliary muscle and sphincter pupillæ by the third nerve, to effect steadily and with precision the most important movement of converging the eyes on a near point. A control on their action is of course provided by the abductors, just as we do not flex our forearm with the biceps and its assistants, without at the same time throwing into action the triceps and other extensors.

"The movement of abduction, similarly tabulating the muscle actions, is seen to be performed by the two obliques with the external rectus, the pure abductor.

| | | | |
|---|---|---|---|
| *Superior oblique* . . | Depressor. | Internal rotator . | Abductor. |
| *Inferior oblique* . . | Elevator. | External rotator . | Abductor. |

"The movement of abduction, being one only of

restitution, is effected, it may be noted, by one muscle supplied by the third nerve, one by the fourth nerve, and one by the sixth nerve.

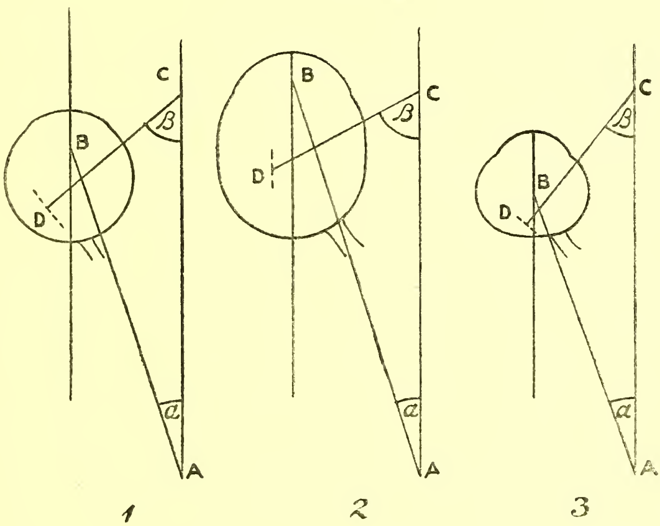
"With the eyes at rest in the primary position we must, I think, assume that the tone of the adductors is exactly balanced by that of the abductors; if not, movement would result; the statement is also probably true that the work done in adducting the eye $1°$ is equal to that done in abducting it to the same extent, though, without some means of estimating the resistance offered to the two movements, I do not think it is capable of proof; but in the position of rest, whether that be one of parallelism of the eyes or of divergent or convergent strabismus, the adductors and abductors are balancing one another. Let us take the case of divergence of axes of the two eyes; it is admitted by all that tenotomy of the external rectus will do less towards correcting a divergent strabismus than tenotomy of the internal rectus will do for a convergent strabismus; regarding the lateral recti as the sole agents of lateral movement, the normally more powerful adductor, attached also at greater advantage (nearer the sclero-corneal junction), when its antagonist is divided and it is unopposed, will do less to supplement our efforts than its more obliging, though feebler, fellow under similar circumstances. This apparent paradox is explained by our recognising that when the external rectus has been divided, the superior and inferior obliques together retain a considerable amount of abducting power, so that the adductors are not left unopposed; when the internal rectus has been tenotomised the superior and inferior rectus in the same way still oppose the abductors somewhat, but have less power than the obliques in the first case. In other words, the superior and inferior obliques together, contribute more to abduction than the superior and inferior recti to adduction of the globe. This

*à priori* is likely if the work done in the two movements be the same, considering that the pure abductor is a smaller muscle acting at less mechanical advantage than the pure adductor.

"If we look also at the angles at which the obliques and superior and inferior recti approach the globe, the idea is further supported. In diagram 1 (*vide infra*), AB represents the line of the superior and inferior recti making an angle $\alpha$ with the sagittal axis; CD the line of the obliques making an angle $\beta$, with the same axis of an emmetropic eye. Berry gives the angle $\alpha$ as 27°, $\beta$ as 51°; according to Swanzy, $\alpha = 20°$, $\beta = 55°$; whilst E. Fuchs gives 23° as the measurement of $\alpha$. The angles support the view that the obliques aid abduction more than the superior and inferior recti aid adduction; they prove nothing, of course, without an accurate knowledge of the power of the respective muscles and the mechanical advantage as regards distance from the centre of rotation at which they get their attachment to the globe. On the question of relative power for lateral movement, the angles shown in diagram 1 are suggestive but not conclusive. I have introduced the diagram with the object of extending its application to myopic and hypermetropic eyes. Let us consider myopia first.

" E. Fuchs, in his generally accepted measurements of eyes and their muscular attachments (von Graefe's *Archives*, xxx., 4, p. 1), states that in myopia the recti muscles are inserted at distances from the sclero-corneal junction not greater than in the normal eye, and we must assume, therefore, that the elongation of the globe does not affect this part of the eye, although it is enlarged in circumference here; the posterior part of the eyeball is the part where especially the elongation takes place which leads to axial myopia; this results, according to Fuchs, in the oblique muscles being attached at points

slightly farther from the posterior pole, though certainly not nearer the centre of lateral rotatory movement, possibly farther from this point. It is well known that myopic eyes are usually prominent ; the posterior pole supported on the retro-ocular tissues will be on the same transverse vertical plane as in the emmetropic or hypermetropic eye, and the globe in elongating becomes more prominent anteriorly ; this will result, I suggest, in the oblique muscles passing more transversely to their insertion and less antero-pos-




teriorly (diagram 2). In other words, the angle $\beta$ is increased ; the angle $\alpha$ is at the same time reduced, for the rectus superior and rectus inferior pass less obliquely forward, having a greater distance in which to arrive at their insertion on the globe whose lateral position with regard to the antero-posterior mid-vertical plane of the orbit is not altered. The increase of the angle $\beta$ seems to me to accord well with Fuchs's observation that the line of insertion of the superior oblique (shown by the dotted line in the diagrams) in myopic eyes is almost constantly more

antero-posterior than in emmetropic or hypermetropic eyes; it is also usually confined to the postero-external quadrant of the globe, its posterior end terminating on the outer side of the vertical meridian of the globe and not transgressing it as in the type of insertion which he regards as typical of hypermetropic and emmetropic eyes. The result of the alteration in the angles of approach of the tendons would result in the abducting power of the oblique muscles being increased in myopia, while the adducting power of the superior and inferior recti would be diminished. In myopia the balance of power is disturbed in favour of the abductors; slight though the advantage gained may be, the total power required to rotate the globe is very small; parallelism now can only be obtained and maintained by volitional impulses constantly imparted to the adductors, and if the incentive to these be diminished by failure of one eye to contribute a practical share to binocular vision, the impulses will not be sent to the adductors, the position of rest will be assumed, *i.e.*, a divergent strabismus will result.

"In the hypermetropic eye, its posterior pole being on the same plane as that of the myopic or of the normal eye, and the globe being small, the superior and inferior rectus would have to pass outwards more abruptly in their course forwards to their insertion; the obliques will have a slightly longer distance in which to pass back to their insertion, and their direction will therefore be a trifle more antero-posterior and less transverse. In hypermetropia the angle $\alpha$ is increased, and the angle $\beta$ is diminished (diagram 3). The balance of power is disturbed in favour of the adductors; this, supplemented by the association of convergence with the necessity to use the accommodation, will result in convergent strabismus as the position of rest, and more probably so if one eye be deficient.

" When abduction is once started, the obliques are placed in a more favourable and steadily improving position to abduct, while the adduction power of the superior and inferior recti diminishes as the axis of the globe comes to lie nearer and nearer to their own axis ; as the globe is adducted, the superior and inferior recti gain in power of contributing to this movement, which the obliques can oppose at less and less advantage.

" I would suggest then that we recognise more fully the combined action of every extra-ocular muscle in effecting even the most simple movement. That we cease altogether to speak of insufficiency of the internal recti. As a cause of divergence, let us substitute predominance of the abductors, and distinguish that condition from insufficiency of the adductors, a term which we may employ to denote the inability to maintain active convergence ; predominance of the adductors will be a factor in causing concomitant convergent strabismus. In using these terms, let us remember that when one group of muscles is predominant, the term is a relative one, and implies that at the same time its antagonistic group of muscles is placed at a mechanical disadvantage. Used with this reservation, passive predominance of one group of muscles will tend to a new position of rest, either of convergence or of divergence ; the strabismus is the result of the new balance of power which has been struck between the adductors and the abductors."

# CHAPTER VII.

## The Eyelids and Lacrimal Apparatus.

*The Eyelids.*—The levator palpebræ superioris muscle arises from the roof of the orbit immediately above and in front of the optic foramen. It expands as it passes forwards and its aponeurosis of insertion is a wide one composed largely of involuntary muscular fibres, which form a sheet that blends with the superior edge of the tarsal plate of the upper lid : a less definite lamina splits off from the anterior aspect of this aponeurosis of insertion and its fibrous bundles, threading their way between the bands of the superior palpebral ligament and through the fibres of the palpebral portion of the orbicularis muscle, give the elevator an indirect attachment to the skin of the lid : there is a third stratum of insertion, deeper than either of the two already described; its delicate strands attach themselves to the conjunctiva at the reflection of the fornix. The levator palpebræ superioris receives its nerve supply from the upper of the two divisions of the oculo-motor; the branches distributed to it enter it on its ocular aspect, usually by perforating the superior rectus.

The shape of the eyelids is preserved by the presence in each of the so-called tarsal cartilage. This is a fairly dense fibrous plate in shape like the letter D ; the straight edge corresponds with the free margin of the lid, the curved border being directed towards its attached base ; the tarsal plate of the upper lid is larger than

that of the lower. The curved edge of the upper tarsal plate is continuous with the superior palpebral ligament; this is a membranous sheet blending at the supra-orbital margin with the periosteum of the frontal bone and attached to the tarsal plate by means of the expanded aponeurotic tendon of the levator palpebræ superioris; the corresponding inferior palpebral ligament in the lower lid blends more directly with the curved edge of its tarsal plate and at the orbital margin becomes continuous with the periosteum of the superior maxilla. The straight edges of the superior and inferior

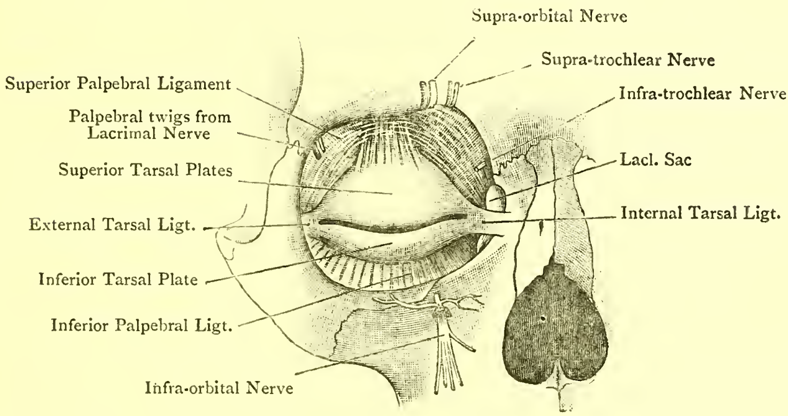



FIG. 16.

Diagram to show Tarsal Plates and the Ligaments of the Eyelids (from Testut, modified).

tarsal plates meet at the internal and external canthi of the palpebral fissure; at the outer canthus some fibres of each tarsal plate are prolonged to form the small external tarsal ligament which gets attachment to the malar bone; the internal tarsal ligament or tendo oculi is similarly formed at the inner canthus but is larger; it passes as a firm band across the front of the lacrimal sac rather above its mid-point, to be attached to the nasal process of the superior maxilla. The internal tendo oculi can be well demon-

strated in the living subject, and the position of the tear sac be accurately appreciated at the same time, by drawing the lids outwards with the thumb applied over the external canthus; by this manœuvre the internal tendo oculi is made to stand forward as a short tense band. Some fibres from the deep aspect of the internal tarsal ligament are found to pass on the back of the lacrimal sac to be attached to the vertical crest on the lacrimal bone in conjunction with the check ligament of the internal rectus muscle. The tarsal plates, with their extensions the superior and inferior palpebral ligaments, and the internal and external tarsal ligaments, form a fibrous diaphragm to the outlet of the orbit, the septum orbitale, which is split by the horizontal aperture—the palpebral fissure.

The skin of the lids is delicate, covered with fine downy hairs and attached very loosely to the subjacent layer by a lax subcutaneous tissue; it is pigmented, the degree of pigmentation varying with the complexion of the subject, and contains small sebaceous glands; at the free margins of the lids it becomes continuous with the mucous membrane on the deep surface of the lids, the palpebral conjunctiva.

The muscle which closes the lids and maintains their free edges in accurate apposition with the globe, performs the act of winking and promotes the circulation of the tears, is the orbicularis palpebrarum. The peripheral part of this muscle, the orbital portion, does not enter into the lids; it is composed of arching fibres which surround the orbital aperture and thus lie upon the bones of the face and cover the origins of the corrugator supercilii and the levator muscles of the upper lip; its fibres are attached internally to the tendo oculi, while others take a direct bony origin from the nasal process of the superior maxilla and the internal angular process; they form a series of loops which have no other

attachment to bone ; as a result, when the orbicularis palpebrarum is strongly contracted as in screwing together the lids, the outer canthus is seen to be appreciably drawn towards the nose ; as they contract, though less violently, in every act of winking these orbital fibres are able to give an impulse to the tears poured into the outer part of the conjunctival sac, and thus to distribute them over the cornea and facilitate their flow to their point of exit.

The palpebral portion of the orbicularis is composed of paler fibres lying upon the anterior surface of the tarsal plates, and running in an arched way between the internal and the external tendo oculi ; these fibres therefore have a fixed point of attachment at each end, but do not directly reach bone. A detached and more definite fasciculus of the palpebral portion is known as the ciliary bundle or muscle of Riolanus ; it lies in the free margin of each lid immediately behind the roots of the eyelashes ; it maintains the edge of the lid in direct contact with the eyeball and is responsible for the accurate direction of the lashes and puncta lacrimalia. Some inner fibres of the ciliary bundle of each lid meet at the inner canthus and pass behind the reflected slip of the internal tarsal ligament on the back of the tear sac, to be directly attached to the vertical crest of the lacrimal bone ; thus there is formed as a specialised portion of the ciliary bundles the single tensor tarsi muscle described by Horner. The tensor tarsi undoubtedly plays a part in the filling and emptying of the lacrimal sac, being assisted in so doing by the elasticity of the sac wall ; whether, however, in the act of winking Horner's muscle withdraws the posterior wall of the sac and so sucks tears into it to be transmitted down the nasal duct by elastic recoil of the sac when the muscle relaxes, or whether contraction of the muscle exerts compression and evacuates the sac which fills itself by elastic expansion between the acts of winking, is not determined ; whichever way it be regarded the tensor tarsi is obviously of first-

rate importance for the purposes of tear transmission to the nose.

The sensory supply of the skin of the lids has been already described ; the upper gains sensation from various branches of the first division of the trigeminus, the lower from the palpebral branches conveyed on to the face by the infra-orbital nerve from the second division.

Motor fibres are carried to all portions of the orbicularis palpebrarum muscle in the temporo-facial division of the seventh nerve, and run in the temporal and malar twigs of this division ; it has already been described how these fibres probably spring in the iter from the third nerve nucleus and join the fibres derived from the facial nucleus by running in the posterior longitudinal bundle.

The eyelashes, a series of short stiff hairs arranged in two or even in three rows, spring where the anterior aspect of the lid becomes continuous with the sharp and square-cut palpebral margin. The roots of the lashes and the sebaceous glands which are associated with them isolate the ciliary bundle lying behind them from the remainder of the palpebral portion of the orbicularis muscle. The lashes are directed almost horizontally forwards but are curved so that those of one lid present a convexity towards those of the other ; the lashes thus lie easily together as the lids are approximated and form an efficient palisade to prevent the entrance of foreign particles. A few small sudoriparous glands are found in the free edges of the lids, also in front of the free border of the tarsal plate ; these are known as the glands of Moll.

The anterior aspect of the tarsal plate upon which the lid muscle directly lies is well defined ; its deep surface is less abruptly delimited ; in this direction the tarsal plate becomes gradually looser in texture and blends with the sub-conjunctival tissue. It is in this looser part of the fibrous tarsus that the Meibomian glands are situated ; they form a series of about thirty tubular glands in each

lid and secrete an oleaginous lubricant which is discharged on the free edge of the lid by ducts opening close to the line of junction of skin and conjunctiva ; the glands with their ducts are arranged in parallel lines at right angles to the lid margin ; their secretion prevents the tears from overflowing on the face ; the orifices of the ducts very readily become blocked, with the result that retention cysts form in the deeper parts of the glands ; in dealing surgically with such tarsal cysts, the chalazion should be incised by a cut from the conjunctival aspect of the lid in the line of the gland affected ; the crucial opening which is sometimes advised or an incision parallel to the lid margin is likely to cut across the lumina of adjacent glands ; if this is done their outlets may become occluded as the result of the operation and the conditions necessary for the formation of further retention cysts be established ; the cysts are obviously most accessible from the conjunctival aspect of the lid, and when they suppurate it is in this direction of least resistance that the small abscess usually tends to evacuate itself ; the whole thickness of the firm tarsal plate intervenes between them and the skin.

The palpebral conjunctiva lines the deep aspect of the lids and is reflected at the fornices on to the globe, becoming at these *culs-de-sac* continuous with the ocular portion of the membrane ; the ocular conjunctiva loosely overlies the anterior part of the sclerotic and blends with Tenon's capsule in this situation ; at the margin of the cornea, the limbus, a more intimate adhesion of the conjunctiva to the enveloping tunic of the globe takes place along the circuit of the sclero-corneal junction ; at the limbus also the conjunctiva is abruptly modified in structure to cover the anterior aspect of the cornea as its transparent stratified epithelium ; taking all parts of the conjunctiva, therefore, into consideration, it is seen that it does form a definite sac, the mouth of the sac being at the

palpebral fissure; the sub-conjunctival layer shows a special development of adenoid tissue in the neighbourhood of the fornices. Near the inner canthus a special fold of the conjunctival mucous membrane is called the plica semilunaris; its concavity is directed towards and is almost concentric with the inner margin of the cornea, and its horns are approximately opposite the puncta lacrimalia; it corresponds with the nictitating membrane or third eyelid of birds. The plica semilunaris and the small fleshy swelling to its inner side, known as the caruncle, are exposed in the innermost part of the palpebral aperture; the lid margins begin to approach one another at the inner end at about the same angle as at the outer, but from the lacrimal papillæ inwards their approach becomes more gradual. The caruncle is a small reddish tumid-looking body, containing sebaceous follicles, and proved on magnification to be a cutaneous structure by the fact that fine hairs can be seen to be growing upon it; it is a not uncommon seat for the development of small papillomata.

Small branches of artery are given to the upper lid by the supra-orbital and frontal branches of the ophthalmic, and to the lower lid by terminal twigs of the third stage of the internal maxillary as it emerges at the infra-orbital foramen; the main supply of each eyelid, however, consists of an arterial arch situated near its free margin between the orbicularis muscle and the tarsal plate; the arches are formed by palpebral branches from the lacrimal artery at the outer end of the lids uniting with corresponding branches from the angular at the inner end; the blood supply to the conjunctiva, caruncle and lacrimal sac is given by these internal palpebral branches from the angular artery.

The blood is drained from the lids in three directions; some flows inwards to join the large angular vein, a

small amount of this being sometimes collected by the small supra-orbital vein; other palpebral veins course outwards and, running above the zygoma between the two layers into which the deep temporal fascia is here split, reach the superficial temporal vein by means of its middle temporal tributary: the remainder of the venous

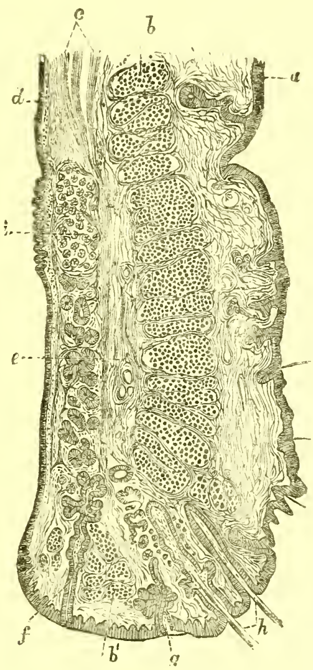



Fig. 17.

Vertical Section through Upper Eyelid (after Waldeyer).
*a*, skin; *b*, orbicularis muscle; *b'*, its ciliary bundle; *c*, Müller's muscle; *d*, conjunctiva; *e*, tarsal plate; *f*, Meibomian gland; *g*, modified sweat gland of Moll; *h*, eyelashes.

blood is directed towards the orbit to join the radicles of the superior ophthalmic vein, and so reaches the cavernous sinus through the sphenoidal fissure; for this purpose venules have to thread their way backwards from the skin of the lids through the fibres of the orbicularis palpebrarum muscle; the blood stream is thus easily impeded in cases of severe blepharospasm, and transudation from the venous

radicles gives rise to œdema of the loose subcutaneous tissue of the eyelids.

The lymphatic vessels from the outer parts of the lids drain into the parotid lymph glands ; this set is situated beneath the parotid portion of the deep cervical fascia; one large gland of the group lies over the root of the zygoma immediately in front of the tragus of the pinna ; the efferent vessels from the parotid glands drain into the submaxillary set lying under cover of the horizontal ramus of the lower jaw, and also into the superficial cervical set lying along the external jugular vein over the sterno-mastoid muscle ; the submaxillary glands in turn drain, to some extent, into the same superficial cervical chain, but mainly into the deep cervical glands accompanying the internal jugular vein. The lymphatic channels from the inner parts of the lids associate themselves with the angular and facial veins and pour their stream directly into the submaxillary glands. The lymph from the orbit drains into the pterygoid region by way of the anterior part of the spheno-maxillary fissure ; here it is received in a set of internal maxillary glands, situated along the corresponding artery and on the side wall of the pharynx ; the internal maxillary glands by their efferent vessels are put into communication with the upper deep cervical glands.

*The Lacrimal Apparatus.*—The lacrimal gland may be compared in size and roughly also in shape to the semi-lunar bone of the carpus. Its convexity is received in and attached to the depression in the bony roof of the orbit immediately behind the external angular process ; its concavity is directed towards the eyeball in the region of the superior and external recti muscles. A small accessory lobule of the gland, the palpebral portion, projects into the base of the upper eyelid beyond the orbital margin, being supported upon the outer part of the

superior fornix conjunctivæ ; this portion is incompletely separated from the main gland by the outer part of the expanded aponeurosis of the levator palpebræ superioris muscle where this sheet passes forwards to reach the upper edge of the tarsal plate. The vessels and nerve of the gland approach it from the depth of the orbit. Through the small palpebral lobe run the half-dozen or more ducts of the main gland, receiving as they do so the secretion from the accessory lobe ; the ducts open in a line through the outer part of the superior fornix.

The tears thus distributed over the outer part of the conjunctival sac are transmitted inwards across the cornea to accumulate in the small recess in the region of the plica semilunaris and caruncle, known as the lacus lacrimalis ; into this collection dip, on the lacrimal papillæ, the two puncta. The puncta are the orifices of the canaliculi, the two small tubes by which the tears are conveyed to the lacrimal sac ; the superior canaliculus is a little longer and narrower than the inferior ; each, at first, courses vertically, but very soon an abrupt bend causes the inferior to take a horizontal direction, while a more acute turn in the superior results in its inner part being directed even somewhat downwards in the final segment of its course to the tear sac. The two canaliculi run approximately at the upper and lower edge of the internal tarsal ligament, and open very close together into the outer wall of the sac.

The lacrimal sac measures about half an inch in length, and is securely lodged in the osseous groove formed by the superior maxillary and lacrimal bones ; the internal tendo oculi crosses the anterior surface of the sac rather above its centre ; Horner's muscle and the reflected slip of the internal tarsal ligament pass behind it ; its walls are elastic ; its lumen, like that of the nasal duct, is elliptical in shape, the major axis of the ellipse being placed antero-posteriorly.

The nasal duct is three-quarters of an inch in length, and opens below into the inferior meatus of the nose. The bones which form its osseous canal are the lacrimal, superior maxillary and inferior turbinate ; it is commonly said that probes passed, one into each nasal duct, meet above on the glabella ; this is certainly not often the case during life ; the duct, with its soft lining *in situ*, is directed downwards and slightly backwards, but very little if at all outwards. The mucous membrane lining the duct is continuous with that of the nose, and forms a valve-like fold, known as the valve of Hasner, which imperfectly covers the opening of the duct into the inferior meatus of the nose. The sub-mucosa, like that over the inferior turbinate bone, is very vascular ; in its deeper layers it becomes continuous with the periosteum of the bony canal, so that it is not surprising that chronic inflammatory disease, starting primarily in the mucous membrane, may eventually induce bone changes.

The duct is occasionally impervious at its lower end at birth. Such congenital atresia gives rise to mucocele in the newly-born child ; the obstruction is usually a delicate membrane, which the use of a small probe, such as can be passed through the unopened canaliculus, will easily dispose of. Congenital absence of the puncta is a not very rare malformation.

It is a not uncommon experience with boxers that, on blowing the nose after a comparatively light blow over the eye, the lids swell up suddenly ; I have had opportunities of seeing such cases of sudden emphysema ; the air appears to find its way only into the subcutaneous tissue of the lids, nose and cheeks, and there is no evidence of its presence in the retro-ocular tissues. I have not been able to detect any bone tenderness, or other evidence suggestive of fracture in these cases, and the blow is usually a trivial one, and delivered with a well padded

glove, so that such a diagnosis seems improbable. I am inclined to think that the blow on the lids puts a sudden strain on the internal tendo oculi and so lacerates the anterior wall of the lacrimal sac to which this ligament is adherent, and that it is by way of the tear passages that the air is forced into the superficial tissues of the face when the nose is blown violently.

# CHAPTER VIII.

## The Ophthalmic Blood Vessels and Intra-Cranial Venous Sinuses.

*The Ophthalmic Blood Vessels.*—The ophthalmic artery springs from the internal carotid as this artery ascends out of the cavernous sinus to the inner side of the anterior clinoid process of the sphenoid bone ; it leaves the cranial cavity enclosed in the same sheath of dura mater as the optic nerve, and lies below and to the outer side of the nerve in the optic foramen. Having gained the orbit, the artery pierces the nerve sheath and gives off the arteria centralis retinæ and the posterior ciliary arteries ; the retinal branch pierces the nerve in the lower and usually outer part of its circumference about half an inch behind the posterior pole of the eyeball ; it runs in the axis of the nerve, gives a nutrient branch to its terminal portion and divides at the papilla into twigs to be distributed in the inner layers of the retina ; the posterior ciliary arteries surround the optic nerve ; one branch of this set on either side, the long ciliary artery, after perforating the sclerotic coat runs forwards in the space between the sclera and choroid at about the level of the horizontal equator and enters the vascular tunic only in the region of the ciliary processes to help in supplying them and the iris with blood ; the greater number of the posterior ciliaries are known as short ciliaries ; they also perforate the sclerotic coat immediately around the optic nerve entrance, but having done so at once break up in the

choroid tunic; twigs of the short ciliaries form an arterial ring round the periphery of the papilla, known as the circle of Haller; between this circle and the central artery of the retina course small capillaries forming a network for the nourishment of the optic disc, and from the circle a cilio-retinal artery is not uncommonly distributed.

The lacrimal artery is a branch given off as the ophthalmic ascends in the orbit before running inwards and forwards above the optic nerve; of considerable size, it gives a recurrent branch to the dura mater of the middle fossa through the outer part of the sphenoidal fissure; this meningeal twig communicates very frequently with the anterior division of the middle meningeal; an enlargement of this anastomosis explains those cases in which the lacrimal or even the whole ophthalmic artery has been observed as a branch of the middle meningeal entering the orbit by the anterior lacerated foramen; a more common abnormality is for the lacrimal to supplement a deficient middle meningeal. The normal lacrimal artery accompanies its nerve along the upper edge of the external rectus muscle; it supplies branches to the tear gland, some of the anterior ciliary arteries, external palpebral branches to the lids and twigs to the forepart of the temporal fossa.

The supra-orbital artery accompanies the nerve of the same name, and besides being distributed to the scalp gives some small branches to the upper eyelid.

The ethmoidal branches arise after the ophthalmic artery has crossed above the optic nerve; the posterior ethmoidal branch is small and leaves the orbit by the posterior internal orbital canal to supply the posterior ethmoidal group of air-cells and the upper part of the nasal cavity: the anterior ethmoidal artery is larger; it gains the upper surface of the cribriform plate by the anterior

internal orbital canal, associated with the nasal nerve, and gives off small meningeal twigs in the anterior cranial fossa ; leaving the skull by a slit alongside the crista galli, it supplies the anterior ethmoidal cells, the frontal sinus and forepart of the nasal roof and still accompanying the nasal nerve may eventually give a few small cutaneous branches.

Having run forwards between the superior oblique and internal rectus muscles, the ophthalmic artery terminates in branches to the skin of the side of the nose, palpebral branches which have been referred to in describing the eyelids and a small frontal artery which accompanies the supra-trochlear nerve around the internal angular process. These terminal branches anastomose with the angular artery, but the communication which is established is less free than that which obtains between the corresponding veins.

Many muscular branches are given off by the ophthalmic in the orbit and from these in turn issue more anterior ciliary arteries to supplement those derived from the lacrimal. Each anterior ciliary artery divides into perforating and episcleral branches ; the former perforate the sclerotic about four millimetres behind the limbus and enter the ciliary processes and iris which they supply with the help of the long ciliary artery on each side ; the episcleral branches, keeping deep to the ocular conjunctiva, run up to the edge of the cornea and are responsible for its nutrition. There is thus a close association between the nutrient supply of the forepart of the sclera and of the cornea on the one hand and that of the ciliary processes and iris on the other ; the phenomenon of congestion myosis in cases of corneal trauma, and the ciliary injection seen in cases of iritis are therefore easily explained on the anatomical basis.

*The Ophthalmic Veins* are two in number, the superior and the inferior. The inferior is the smaller and is

derived from the union of some of the inferior muscular branches with the lower posterior ciliary veins; the posterior ciliary veins are constituted by the four or five venæ vorticosæ after they have emerged from the choroid and obliquely perforated the sclerotic about midway between the corneal margin and the optic nerve. The inferior ophthalmic vein leaves the orbit by the sphenoidal fissure, and opens into the anterior end of the cavernous sinus, either independent of or in conjunction with the superior ophthalmic vein; it establishes at the same time a communication through the spheno-maxillary fissure with the pterygoid venous plexus, and may occasionallv empty itself entirely in this direction.

The superior ophthalmic is the main vein of the orbit; it commences at the internal angular process, where its radicles have free communications with the angular vein; in traversing the length of the orbit it receives all the tributaries corresponding to the branches of the ophthalmic artery which the inferior vein has not collected. Its course is identical with that of the artery, except for the fact that it leaves the orbit by the sphenoidal fissure and not by the optic foramen, to join the cavernous sinus. The central vein of the retina commonly drains directly into the cavernous sinus; when it does so, however, it maintains a communication with the superior ophthalmic vein, into which it may at other times entirely empty itself; these varieties, and especially the direct vein to the cavernous sinus, are of particular interest in relation to vascular disturbances in the retina visible with the ophthalmoscope. There are anterior ciliary veins corresponding to the arteries of the same name; they drain into the muscular tributaries of the ophthalmic veins; it is these anterior ciliary veins which become passively distended and show as dark serpentine vessels on the anterior part of the sclerotic in cases of chronic

glaucoma; the return of blood through the oblique apertures in the sclera, which the venæ vorticosæ traverse, is mechanically impeded by the increase of tension; the blood, therefore, finds its way into the anterior part of the vascular tunic, and discovering easier exits by the perforating tributaries of the anterior ciliary veins fills up the latter.

*The Cavernous Sinus* lies upon the lateral aspect of the sphenoid bone, taking an antero-posterior direction. Its outer wall (fig. 10) is firm and obliquely set, so as to face upwards and outwards, and encloses the third, the fourth, and the ophthalmic division of the fifth nerves. When these nerves first enter the lateral wall of the sinus from behind they occupy positions in the order of their numbers from above downwards; tracing them forwards, the fourth nerve is found to ascend till it displaces the third from the highest position, while the third nerve divides into its upper and lower divisions, which become separated by the nasal branch of the ophthalmic division of the fifth where they all pass into the orbit through the sphenoidal fissure; the ophthalmic division of the fifth, by the time the orbit is reached, is represented by the nasal, frontal and lacrimal nerves; the two latter pass through the sphenoidal fissure on about the same horizontal plane as the fourth nerve, the lacrimal being the most external and the fourth the most internal of the three.

The sixth nerve lies amid the trabeculæ which traverse the spongy cavity of the cavernous sinus rather than in its lateral wall; it maintains a close relationship to the internal carotid artery, which is taking a sinuous course in the interior of the sinus in contact with the body of the sphenoid bone before ascending to the inner side of the anterior clinoid process; the abducens passes out of the sinus the lowest of all the nerves which enter the

orbit through the sphenoidal fissure. Quite in the posterior part of the lateral wall of the cavernous sinus and close to its floor the second division of the fifth nerve is to be found ; it soon passes out of relationship to the sinus as it leaves the skull for the spheno-maxillary fossa by the foramen rotundum.

Internally, the cavernous sinus is separated from the sphenoidal air-cell only by the thin lateral wall of the body of the sphenoid bone ; at a higher level the pituitary body lies immediately internal to the sinus, and inter-cavernous sinuses are traceable across the sella turcica in front of, behind and below the hypophysis cerebri ; the spongy tissue of the two cavernous sinuses is really continuous across the mid-line below the diaphragma sellæ, and the description of a circular sinus at the base, composed of one anterior and one posterior inter-cavernous sinus is unduly artificial ; moreover, behind the dorsum sellæ the cavernous sinuses are in communication by a network of venous channels across the basi-sphenoid bone : similar channels unite the two inferior petrosal sinuses across the basi-occipital bone ; this plexus of veins has been designated the basilar sinus ; it directly communicates with the anterior veins of the spinal canal at the foramen magnum.

The main tributaries of the cavernous sinus are the superior and inferior ophthalmic veins, either independently of one another or as a single vein ; the central vein of the retina may, in some instances, be found to form an additional tributary. The spheno-parietal sinus, or sinus alæ parvæ, is a small vein which receives a branch from the dura mater, communicates with the middle meningeal veins, and runs along the lesser wing of the sphenoid in a fold of the dura mater to join the anterior end of the cavernous sinus above the third nerve ; it is occasionally absent, and on the other hand is sometimes

of large size and receives the termination of the middle cerebral vein ; another point of interest, also, to the ophthalmologist is, that it sometimes joins the superior ophthalmic vein instead of passing directly to the cavernous sinus. Small inferior cerebral veins join the cavernous sinus ; posteriorly, it is drained by the superior and inferior petrosal sinuses. The superior is longer but smaller than the inferior petrosal sinus ; it follows the upper border of the petrous bone in the attached edge of the tentorium cerebelli ; it receives cerebellar and inferior cerebral veins and a vein, small in size but of great pathological significance, which joins it from the middle ear through the petro-squamous suture ; it opens into the lateral sinus where this is abruptly bending to pass downwards on the inner side of the mastoid bone. The larger inferior petrosal sinus follows the petro-occipital suture to the jugular foramen (foramen lacerum posterius) ; the sixth nerve perforates the dura mater and passes forwards on the base of the skull in close proximity to the sinus ; having received as tributaries some inferior cerebellar veins and auditory veins from the internal ear, the inferior petrosal sinus leaves the cranial cavity by the anterior compartment of the foramen lacerum posterius, and joins the internal jugular vein just outside the skull. The so-called basilar sinus and its connections with the inferior petrosal sinuses have been already described.

Emissary veins through the foramen ovale, the foramen Vesalii and the foramen lacerum medium, put the cavernous sinus in communication with the pterygoid and pharyngeal venous plexuses ; a fine venous network from the cavernous sinus accompanies the carotid artery in its winding course through the petrous bone and eventually joins the internal jugular vein.

The possibilities of the spread of septic material by venous channels to and from the cavernous sinus

are therefore very extensive; sphenoidal empyema may involve the sinus in thrombosis and the nerves in its wall in paralysis; fracture across the middle fossa of the base of the skull may give rise to arterio-venous aneurism; the sixth nerve is more commonly implicated if a fissured fracture of the base involving the middle or posterior fossa runs across the apex of the petrous bone; the different ways in which the ophthalmic veins and their tributaries may unite with the sinus will with advantage be recalled when endeavouring to explain differences in the ophthalmoscopic appearances of cases which might have been expected to show identical vascular changes.

Windle examined the circle of Willis in 200 cases and found only 119 were normal; the posterior communicating arteries are very commonly of unequal size, the right being usually the larger; they sometimes connect anteriorly with the middle cerebrals instead of with the internal carotids. A posterior communicating artery is sometimes wanting, or fails to join the posterior cerebral; on the other hand, the latter artery is not infrequently derived from an enlarged posterior communicating, its connection with the basilar being rudimentary or absent.

In the treatment of arterio-venous aneurism in the cavernous sinus it is usually advised that the common carotid artery be ligatured; this procedure usually ameliorates the condition, but, after an interval of some weeks or months, return of pulsation with recrudescence of the distressing symptoms occurs in a considerable proportion of the cases. This is no doubt due to blood entering the upper end of the internal carotid artery through the circle of Willis; it flows in a downward direction through the internal carotid in order that it may again ascend in the external carotid on the same side; in so doing it re-establishes pulsation in the aneurismal sac, while it acts as a permanent deleterious

drain on the already curtailed cerebral circulation. It is reasonable to think that a greater proportion of these cases would be cured if the internal carotid artery and not the common carotid were tied in the neck on the affected side; there would then be no possibility of the establishment of a reversed blood current in the internal carotid; the territory of the external carotid would still be supplied with blood in the normal way, while stasis and coagulation would be much more efficiently promoted in the aneurismal sac. It is probable that if this procedure is adopted in the treatment of arterio-venous aneurism of the cavernous sinus success will still be variable, but a far greater proportion of cures should be obtained than by ligaturing the common carotid; an element of uncertainty, over which we have no control, will still exist, owing to the very numerous varieties which the circle of Willis may present.

# CHAPTER IX.

## The Orbit and Surrounding Air-Cells. Some Points in Development.

*The Orbit and its Surrounding Air-Cells.*—The orbit is usually described as a pyramidal-shaped cavity. If this comparison is to be accepted it requires to be qualified. The pyramid is a four-sided one with rounded angles; its inner wall forms a vertical plane running in the sagittal axis; its outer wall diverges at an angle of about 45° with this axis; the floor is fairly horizontal, but the slightly vaulted roof depends anteriorly so that the supra-orbital margin may form a more efficient protection to the orbital contents; this overhanging is especially shown by the outer part of the upper edge of the orbit owing to the presence in the roof behind the external angular process of the depression for the lacrimal gland. Sections made transversely across the orbit show it to be more of an oblique cone than a pyramid as its apex is approached; it is only near the outlet that the quadrilateral shape is conspicuously shown.

The bones which enter into the formation of the inner wall of the orbit are, from before backwards, the nasal process of the superior maxilla, the lacrimal, the os planum of the ethmoid and the body of the sphenoid; it is at once recognised that of these the nasal process of the superior maxilla is the stoutest; the others are all delicate plates. The roof, mainly formed by the horizontal plate of the frontal, is completed posteriorly by the

lesser wing of the sphenoid ; the supra-orbital margin is the strongest part of the roof. The orbital processes of the malar in front and of the palate bone behind complete the floor which is, in the greater part of its extent, formed by the orbital surface of the superior maxilla ; here again the bone is strongest at the outlet. The oblique outer wall is formed by the frontal process and orbital plate of the malar and posteriorly by the great wing of the sphenoid ; this external wall is stout at the outlet and everywhere strong ; sections show that its thickness increases as the apex of the orbit is approached ; in this connection it is to be noted that the outer is the only wall of the orbit exposed to direct violence ; on all other sides the bony walls form delicate septa separating the orbital contents from surrounding cavities. For purposes of protection also it is obviously advantageous that all the bones should be strong at the outlet, as we have seen them to be. Attention may also be drawn in this connection to the fact that at birth the orbit shows a well ossified bony outlet ; ossification commences, for example, in the frontal bone at the junction of its horizontal and vertical plates and spreads thence into each ; the nasal process of the superior maxilla is the site of an ossific deposit at an equally early period of fœtal life, while the malar bone is also the seat of early intra-uterine ossification ; the eyeball is therefore well protected from stress and injury during parturition. When we recollect the relatively large size and the advanced stage of development of the eye at birth, it is clearly especially desirable that such protection should be afforded ; that it is efficacious the rarity of birth injuries of the globe in cases of unassisted labour can testify. The obstetrician regards the fœtal skull as composed of the compressible vault, and of the incompressible base including the face ; the early ossification of the bones of the base and face affords the security against injury which the

important nerve structures and special sense organs enjoy as the child's head passes through the maternal pelvis.

The outer wall of the orbit is separated in the main from the roof and floor by the sphenoidal and spheno-maxillary fissures respectively. The former fissure is a narrow slit between the great and small wings of the sphenoid, but rather wider at its inner and posterior extremity where the optic foramen lies immediately above it and to its inner side ; the structures passing through this foramen lacerum anterius have already been sufficiently described. The spheno-maxillary fissure meets the sphenoidal fissure near the apex of the orbit ; its lips are formed above by the lower edge of the orbital plate of the sphenoid and below by the orbital surfaces of the palate and superior maxilla ; anteriorly the fissure terminates in a variable way ; most often it is completed by the orbital process of the malar ; occasionally, however, the maxilla and great wing of the sphenoid come into articulation in front, while in other cases the malar is excluded by the development of a Wormian bone. The spheno-maxillary fissure, bridged across in the recent state by a fibrous diaphragm containing elements of involuntary muscle, puts the orbit into communication posteriorly with the spheno-maxillary fossa and anteriorly with the zygomatic fossa ; running forwards from the fissure there is seen on the floor of the orbit the infra-orbital groove, deepening as it advances until it becomes a closed canal which emerges on the facial aspect of the superior maxilla at the infra-orbital foramen ; the groove and canal lodge the terminal branch of the second division of the fifth nerve and of the third stage of the internal maxillary artery.

The orbit is surrounded in adult life on three sides by air sinuses in communication with the nasal cavity. Beneath the floor lies the antrum of Highmore, an air-cell in the body of the superior maxilla which is

present at birth, and which in adult life attains a large size; signs of its development are first seen in the fourth month of fœtal life; its walls are thick in childhood but become thinner as age advances; in the superior wall of the pyramidal-shaped cavity run the infra-orbital nerve and the termination of the internal maxillary artery; the nerve gives off dental branches which descend in the lateral and the anterior walls of the antrum to the teeth of the upper jaw.

In the roof of the orbit lies the frontal sinus, which extends also upwards in the vertical plate of the frontal bone; the cell begins to develop during the second year of life and goes on increasing in size by absorption of the diploe of both plates of the frontal bone until old age; the body of the cavity lies behind the glabella while it extends outwards over the inner two-thirds of the orbit and backwards in its roof for quite half an inch; it is separated from its fellow by a bony septum which is usually imperfect, and it communicates with the middle meatus of the nose by an elongated anterior ethmoidal cell known as the infundibulum. In the lower and posterior part of a groove continuing the line of the infundibulum opens the antrum of Highmore; this opening, large in the disarticulated skull, is observed to be placed well above the level of the floor of the maxillary sinus; these anatomical arrangements allow the discharges of a frontal empyema to readily find their way into the antrum, while the opening provided by Nature for the passage of air into the antrum forms a very unsatisfactory drain for a fluid collection in the same cavity; moreover, in the articulated skull the size of the antral opening is much reduced, being overlapped by the vertical plate of the palate, the ethmoidal process of the inferior turbinate bone and the uncinate process of the ethmoid.

The cells in the lateral mass of the ethmoid are

divided into an anterior and a posterior group, which are independent of one another. The anterior group opens into the middle meatus in association with the infundibulum. The posterior set opens into the superior meatus of the nose and sometimes communicates with the sphenoidal air sinus. The cells of both groups are separated from the orbit by the os planum of the ethmoid; the lateral mass of this bone, when it is disarticulated, shows many incomplete cells; in the articulated skull they are completed, in front by the nasal process of the superior maxilla and the lacrimal bone, below by the maxilla and the orbital process of the palate, behind by the sphenoidal turbinate and above by the frontal bone. The lateral mass begins to be hollowed by air-cells in the fourth or fifth year of childhood, but an indication of the ethmoidal air sinus can be detected even in fœtal life.

The sphenoidal air-cells are two in number; they lie side by side in the body of the sphenoid bone and in exceptional cases may, late in life, even encroach on the basi-occipital bone; the vertical septum between them is usually imperfect. The lateral wall separates the cell from the apex of the orbit and optic foramen and more posteriorly from the cavernous blood sinus and the structures associated in its walls; above the cells lie the olivary eminence with the optic chiasma, and the sella turcica occupied by the pituitary body. The sinus is said to be an extension from an air-cell formed after birth by the folding round of the sphenoidal turbinate bone into a hollow pyramid; the cell invades the body of the true sphenoid about the seventh year. The communication with the nose is by an aperture close to the nasal roof above the superior meatus in the spheno-ethmoidal recess.

Fractures running across the walls which separate any of the above air-cells from the orbit are likely to be

followed by emphysema of the retro-ocular tissues and eyelids, the air leakage occurring in the act of blowing the nose. Chronic empyemata of the ethmoidal cells may cause the os planum to bulge towards the orbit and eventually perforate it; Knapp and others have opened and drained such collections by dissecting down to them along the inner wall of the orbit, and in other cases the empyema has spontaneously evacuated itself by this route. It is not surprising that in such cases no emphysema of the soft tissues occurs, when we reflect that obliteration of the communication between the air-cell and the nose must necessarily precede the development of the mucocele.

In the operation of laying open the frontal sinus it is necessary to recollect that the air-cell is largest near to the glabella ; cases have occurred in which the dura mater has been wounded, with serious results, when the trephine has been applied too far out or too far up upon the vertical plate of the frontal bone ; at the same time it is necessary to guard against using the trephine too low or too far back behind the internal angular process, or the pulley of the superior oblique muscle may be interfered with ; when a small disc of bone has been removed the opening can be safely enlarged in any required direction with a cutting forceps.

The periosteum is easily detached from the flat bones constituting the walls of the orbit, but at its borders is much more firmly adherent. The freedom with which the periosteum can be separated with a raspatory greatly facilitates such procedures as exenteration of the orbit and Krönlein's operation. At the apex of the cavity the periosteum becomes continuous with the dura mater and the sheath of the optic nerve.

The eyeball is not situated in the exact centre of the orbital outlet, but rather to its inner side ; for this reason access to the depth of the orbit, in order to deal with

retro-ocular growths, is as a rule obtained on the outer side of the globe. This is likely to be still more the method of procedure in the future with the increased facilities which Krönlein's resection of the outer wall affords. Of the bone cuts for this operation an examination of the skull shows that the upper section, though directed obliquely backwards, is not far removed from the vertical and hits off the spheno-maxillary fissure a very short distance behind its blind anterior limit ; on the skull a line from the external angular process to the last molar tooth gives approximately the direction ; the lower part of the cut corresponds pretty closely with the suture between the malar bone and orbital surface of the great wing of the sphenoid; if it is made further back than this the outer orbital wall is thicker and more resistant, and the spheno-maxillary fossa may be opened up, a complication which it is desirable to avoid. The lower bone cut is as near as possible horizontal in direction and joins the blind anterior end of the spheno-maxillary fissure.

If surgical procedures are to be designed which will enable us to deal with septic thrombosis of the cavernous sinus in the way that lateral sinus pyæmia is now dealt with, I believe access must be gained through the eviscerated orbit ; the sacrifice of a disorganised eyeball will be a matter of no importance if it enables us to cope with so fatal a mischief; to reach the sinus effectually through the maxillary antrum, guided by the infra-orbital nerve, is a much more cramped proceeding; the only practical alternative is to follow the lateral route corresponding to that chosen for the extirpation of the Gasserian ganglion ; unfortunately the orbital method will only lead to the anterior end of the sinus ; if it can be reached in any way the relation of the internal carotid artery must be carefully borne in mind ; venous hæmorrhage need not be dreaded ; it is unlikely to occur and if encountered could be readily controlled by plugging.

It may be well to point attention here to a fairly common injury which demands more thorough surgical attention than it often receives. Punctured wounds through the lids are not rarely inflicted with the points of walking sticks or umbrellas; too much care cannot be exercised in the examination of these patients; the thin roof of the orbit may readily be fractured by direct violence in such cases; a punctured fracture in this situation, having lacerated the dura mater, will involve the orbital aspect of the frontal lobe, and no distinctive nerve symptoms will probably be present to arouse suspicion; a punctured fracture of the base of the anterior fossa demands no less care than a puncture of the vault of the skull invariably receives; for want of such treatment many patients have died of septic meningitis whose lives might have been saved; the serious possibilities should be present to the mind of the surgeon and he will not fail to treat the case at the outset with respect, but immediately give to it the surgical attention which all punctured fractures of the skull urgently require.

*Some Points in Development.*—The cleft of the orbit is, in the early embryo, in continuity with the primitive mouth or stomodæum by means of a wide cleft known as the orbito-nasal fissure—the fissure lies between the maxillary process and the lateral part of the fronto-nasal plate, sometimes called the lateral nasal process. The median portion of the fronto-nasal plate is responsible for the formation of the columella of the nose and the philtrum of the upper lip; the lateral nasal processes grow round the primary olfactory pits, and so form the anterior nares. As the fronto-nasal process grows the orbito-nasal fissure increases in length; at the same time the maxillary process extends inwards to meet the median nasal process below and so complete the nostril and to meet the lateral nasal process above. The upper part of

the orbito-nasal fissure persists, however, as a cleft which becomes the orbit, while the lower part of it is merely covered over by a superficial union of the maxillary and lateral nasal processes so as to leave deeply the canal which constitutes the tear passages; the superficial line of fusion between the maxillary process and fronto-nasal plate is indicated on the face by the naso-facial sulcus. It is therefore in this naso-facial groove that from faulty development a fissure may be found, or puckerings or dimples in the skin, which may or may not communicate as complete congenital fistulæ with the tear passage; in the same sulcus from inclusion of epidermal elements well-developed dermoid cysts may be met with.

The palatal processes of the superior maxillæ develop later, and with the premaxilla derived from the fronto-nasal process divide the primitive mouth into the buccal and the nasal cavities. Congenital atresia of the tear-passage is generally met with either at the lower end of the nasal duct or in the form of absence of the puncta or canaliculi; the former condition will be accompanied by congenital mucocele; the diaphragm across the lower end of the nasal duct is usually a very delicate one; the passage of a small probe into the nose *viâ* the canaliculus, which need not be slit for the purpose, usually suffices to deal with the malformation and to cure the mucocele.

D. Gunn has reported some interesting cases of congenital distension of the lacrimal sac; he is of opinion that in some of these the obstruction to the nasal duct is due to persistence in the nose of fœtal cartilages that should have disappeared long before birth; one such is a layer that connects the cartilaginous ethmoid above with the lateral cartilage of the nose below.

The superior maxillæ and the malar bones develop as membrane bones in the superficial part of the maxillary plates, and the lacrimal bone is derived from a similar ossification;

the lower eyelid forms as a cutaneous fold in connection with the superficial part of the maxillary plate. Cases have been described by Treacher Collins and by Berry, in which congenital notches in the outer part of the lower lid have been accompanied by flattening of the cheek due to faulty development of the malar bone on the side affected ; the association between the two deformities is an obvious one. The more ordinary coloboma of the lower lid is a cleft nearer its inner than its outer end and taking a downward and inward direction : a similar coloboma

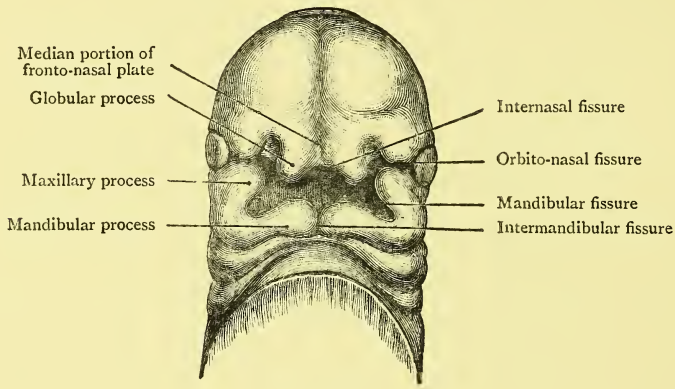



Fig. 18.
Head of an Early Embryo. (Modified from His.)

is also frequently observed from faulty development of the upper lid : the exact cause of such notching does not seem to be determined ; it is frequently associated with the presence on the globe of a small nodule of skin described as a congenital mole or dermoid of the conjunctiva. The folds which form the eyelids are at first skin-lined, both on their superficial and their ocular surfaces ; when, in the embryo, they have met to completely cover the globe, the skin on the eyeball and that on the ocular surface of the lids becomes converted into a delicate mucous membrane ; if in a notch or

coloboma of either lid a portion of this tissue of cutaneous origin is still superficially exposed it undergoes in this situation no such metamorphosis as is necessary for it to assume the nature of the normal conjunctiva, but develops and persists as a dermal growth. An epibulbar dermoid, therefore, frequently corresponds in position with the cleft in a colobomatous eyelid, but it is not accurate to regard the dermoid as representing the tissue which should have filled in the gap in the eyelid.

Dermoid cysts are found both at the inner and the outer part of the upper lid, close to the angular processes

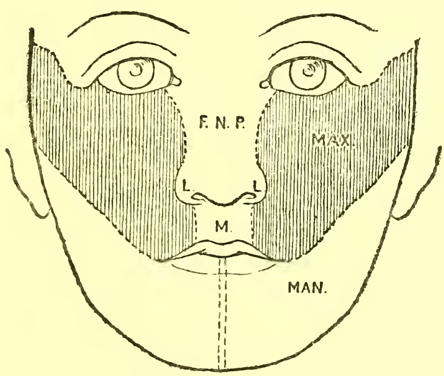



FIG. 19.

Showing the development of the face (modified from Merkel). F.N.P., part formed from the fronto-nasa process; L., from its lateral nasal; and M., from its mesial portions. MAX., formed by the maxillary process. MAN., formed by the mandibular process. (From Treves' "Surgical Applied Anatomy.")

of the frontal bone, but sometimes extending more deeply into the orbit. Some light is thrown on their presence in the lateral parts of the lid, when we recollect that at the inner side the nasal process of the maxilla and the lacrimal bone, and at the outer side the malar bone, are superficial ossifications in the maxillary plate; the cysts are therefore found in situations where fusion between the maxillary and fronto-nasal plates has to take place and where inclusion of an epidermal element is likely to occur. Some defective formation of bone is very common

where these dermoids are present, and a dermoid at the inner side of the upper lid may have a pedicle in continuity with the dura mater, so completely has its early presence in connection with the dura prevented the development of the osseous tissue. Dermoids at the external angular process or in the temporal region may be associated with defective formation of the outer wall of the orbit ; the line of suture between the orbital plate of the malar and the great wing of the sphenoid may perhaps be assumed to indicate the limit to which the normal maxillary plate extends in this direction.

Small dermoid cysts are occasionally found, however, in the middle portion of the upper lid ; they are said to be unattached to either bone or periosteum when met with in this situation ; they are considered to be formed in the recess between the fronto-nasal plate and the skin fold which forms the upper lid, and are in consequence less deeply placed than the cysts which occur at the lateral angles, and unaccompanied by any depression in the adjacent part of the orbital margin.

# PART II.

## *Illustrative Cases.*

## Case 1.

*Illustrative of Ocular Symptoms in Tabes Dorsalis.*

The frequency with which primary optic atrophy occurs in cases of tabes dorsalis is perhaps apt to be estimated too high by ophthalmic surgeons; patients with locomotor ataxy who present no ocular symptoms do not of course as a rule come under the observation of the ophthalmologist; on the other hand, as a set off to this source of error, it is well known that a very long time after primary optic atrophy has become complete, further symptoms of tabes dorsalis may begin to reveal themselves. Gowers estimates that about one case in nine is the subject of atrophy of optic nerves, and we may perhaps with fair accuracy regard the proportion as about 10 per cent.

Transitory ophthalmoplegia externa occurs probably in about 30 per cent. of all cases of locomotor ataxy, but a history of diplopia is not asked for or obtained as regularly as it might be. The following brief note of a case is a fair example of the ocular signs of locomotor ataxy; the cases of optic atrophy need no illustration.

T. R., coachman, aged 46, came to me at the Moorfields Hospital on April 28, 1903. He was complaining of seeing double during the last week; had never done so before; he had received no head injury and knew of nothing to account for it. I found that he had very imperfect power of abduction of the right eye, and that attempts to move the eye in this direction were accompanied by nystagmic jerks of large excursion; no elaborate tests or

charts of the double images were needed to show that the external rectus muscle of the right eye was paretic. In the left eye abduction could be fully performed, but with slight nystagmic jerks at its completion.

The pupils were not the subject of spinal myosis, but were unequal; in diffuse daylight the left pupil was a shade larger than the right; in the dark room the inequality was the exact opposite of this—this was found to be due to the fact that the left pupil was quite uninfluenced in size by changes in the intensity of the illumination to which it was exposed, while the pupil of the right eye was responsive to light stimulus, although sluggish in this respect; there were no adhesions of either iris, and each pupil acted with normal readiness when the eyes were converged to fix a near point. The left pupil showed the typical Argyll-Robertson phenomenon, while the right approximated to it.

The patellar tendon reflex was quite absent in each leg.

The co-ordination of the muscles of the lower limbs was slightly impaired; the patient swayed unduly when standing with feet together and eyes closed. There was no numbness or disordered sensation in the feet.

During the past six months T. R. had frequently suffered from attacks of severe abdominal pain extending round into the lumbar regions; they did not double him up and were not accompanied by vomiting, and from the description given appeared to me to be of the girdle character. No other crises or lightning pains were complained of, but he had latterly been much troubled with constipation and the bowels rarely acted without purgatives. There was no optic atrophy.

The diagnosis of the case cannot be doubted. The ophthalmoplegia externa in all probability will have proved temporary.

The pupillary condition is interesting; the absence of

spinal myosis in tabes cases is, in my experience, more common than its presence, though the sign is not infrequently a well-marked one. The well-developed Argyll-Robertson pupil on one side only is a little unusual; no doubt in a later stage of the case this want of symmetry will have vanished as the disease advances—such unilateral examples of the pupillary phenomenon afford a basis for speculation as to the site of the lesion on which the loss of the reaction to light in these patients depends—if an autopsy is made on a patient who is known during life to have presented the Argyll-Robertson pupil in one eye only, careful pathological investigation might not improbably result in adding to our knowledge in this respect.

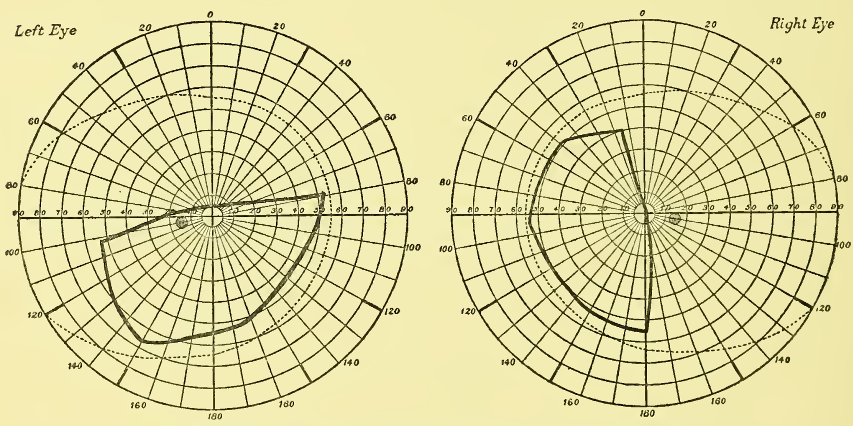
Optic atrophy was not present in the case of T. R. Gowers states that when present the primary atrophy of locomotor ataxy may stop short at the chiasma, but Turck has discovered that very often, at least, the fibres of the optic tracts are also wasted, and degenerative changes can be found in the external corpora geniculata. Even in long-standing cases of primary gray atrophy it is only the nerve fibre and ganglionic cell layers of the retina which are degenerate; changes are not found in any layer outside that of the ganglion cells.

## Case 2.

### *Bi-temporal Hemianopia from Chiasma Lesion.*

W. M., aged 48, male, a storekeeper, saw me at the Moorfields Eye Hospital on August 18, 1900. He was complaining of a mist in front of the eyes during the previous three months; of inability to recognise people or to read; he was under the impression that his vision was better in dull light; he had formerly smoked two pipes of tobacco a day but had discontinued this seven weeks before

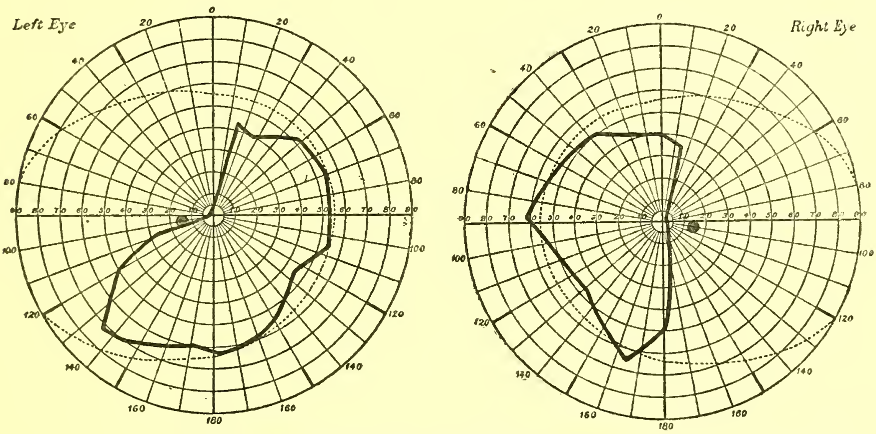
his visit. The vision of either eye was found to be only 1-60th and 20 J.; ophthalmoscopically the discs were conspicuously pale and the lamina cribrosa unduly exposed in each; the arteries were rather too small. So far the case resembles fairly closely a case of tobacco amblyopia, and affords me an opportunity of drawing attention to the fact emphasised by Nettleship, that central amblyopia is not infrequently an early symptom in tumour at the chiasma; that the central defect causes the cases to simulate examples of toxic amblyopia; that the failure of the patient to recover, when placed under favourable conditions, arouses suspicion, and that later the apparent central scotoma will be found to have increased until the fields become of the bi-temporal hemiopic type characteristic of chiasma lesions. Nettleship records examples in vol. xvii., *Trans. Ophth. Society*.




W. M.—Fields for white, in fair daylight; test spot 10 mm. September 1, 1900.

In W. M.'s case there were, however, a few additional suggestive points in the history. He had contracted a venereal chancre thirty years ago, which was cauterised and lasted about three weeks; there were no sequelæ, except suppurating buboes, as far as he recollected; medicinal treatment in the shape of pills was administered for four or five weeks, and the gums became sore as the result.

He had had rheumatic fever twenty-eight years ago, but no general illness of any importance since. Three years before I saw him he said he had suffered temporarily from squint ; " the doctor tested it with a candle " ; he stated " that the left eye went back into position in three weeks and the right in seven weeks." I do not pretend to be able to unravel these statements, but they may, I think, be taken with reasonable certainty to mean that he had been the subject of external ophthalmoplegia ; the position of the motor nerves of the eyeball and their proximity while in the cavernous sinus wall to the pituitary fossa will be recalled.




W. M.—Fields for white ; test spot 10 mm. September 29, 1900.

The patient's knee-jerks were normal ; there was no inco-ordination. Biniodide mixture was ordered.

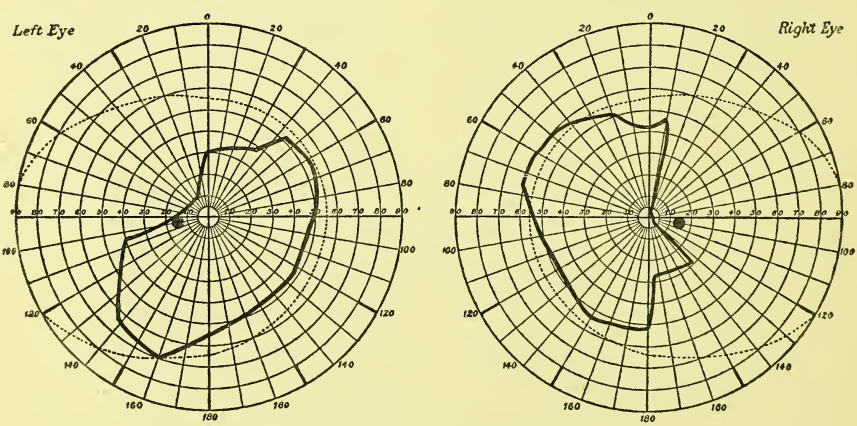
The fields were not taken until a fortnight later ; I did not personally chart them and remarked upon them that they were very unusual, but suggestive of a chiasma lesion. At this visit the pupils were found to be quite inactive, both to light stimulus and with convergence. Ante-syphilitic treatment was continued.

One month later I examined the fields myself with the perimeter and charted them as above.

I was satisfied that the fields were of the bi-temporal hemiopic type, and sent the patient to Dr. Jas. Taylor, who agreed on this point. He ascertained that W. M. had increased a stone in weight in the previous twelve months, and regarded this as suggestive of a growth of the pituitary body; by Dr. Taylor's advice two tabellæ of thyroid gland extract were administered daily.

There was never any affection or loss of the olfactory sense, and no discharge from the nose had at any time been observed. Sensation over the fifth nerve areas was quite normal.

On November 10, 1900, the ophthalmoscopic picture was the same; I was not sure whether the veins of the retinæ were unduly full, or whether the increase of size was only apparent in contrast with the undoubted diminution in calibre of the arteries; I observed an arterial loop on the right disc which distinctly pulsated, but there was no general rhythmic beat in the arteries. I recorded the fields of vision again myself as under:—




W. M.—Fields for white; spot 10 mm., in good light. November 10, 1900.

The bi-temporal hemiopia is seen again distinctly and not materially altered from the condition I had charted ten weeks earlier. The patient was aware that if he wished

with either eye to see my face as clearly as possible, it was necessary for him to direct the eye obliquely; I observed that he did so in such a way that the image would fall on the temporal part of the retina in use. The pupils at this visit were unequal in size; the right measured 5 mm. and the left 4 mm.; they gave no response to the stimulus either of light, or of convergence of visual axes. For a week in the latter part of October he had experienced aching pain at the back of the head, "so severe it had left the back of the head quite sore." In the early part of November on six or seven occasions a sharp pain had taken him in the back of the right thigh, "like a knife running through it." The movements of the eyes were normal, and there was no proptosis or sense of resistance when backward pressure was made upon the eyeballs. The vision was unaltered. With Dr. Taylor's concurrence I resumed the previous dose of gr. x. of potass. iodid.

By the end of November the patient had lost 14 lbs. in weight: he came from the country; his doctor wrote me in the middle of December, 1900, that W. M. had shown characteristic symptoms of thyroidism which ceased when the tabellæ were discontinued. He did not further attend at the hospital.

On April 13, 1903, in reply to enquiry from me, his doctor wrote that W. M. was still alive; his sight was reduced to perception of light; he could make out no appreciable difference between the temporal and the nasal halves of the fields; he had developed no general signs of cerebral tumour; the optic discs were in a state of advanced atrophy.

### Case 3.

*Retro-bulbar Neuritis, accompanied by Proptosis and Limitation of Movement of the Eyeball.*

Mrs. C—, aged 24, came under my care as an out-patient at the Moorfields Hospital on February 19, 1902.

She had been suffering for fourteen days from neuralgic pain in the left eye and over the left side of the vertex of the head; at the time of onset of the pain the left eye was observed to be prominent; the prominence was said to be diminishing and some puffiness and swelling of lids, which she had observed, had disappeared by the time she paid her first visit to the hospital. One week after the onset of pain she noticed a thin mist which was gradually getting more dense over the sight of the left eye. The patient was suckling her first baby, aged four months; she looked pale and weakly and had not felt strong since her confinement. She had fainted frequently during her pregnancy and suffered from vomiting but the sickness had not been of any unusual severity.

On examination the left eyeball looked normal in appearance, but was slightly proptosed in a direction forwards and outwards; there was some limitation in its movement of depression; in all other directions the movements were unimpaired. A sense of resistance which was not present on the right side could be appreciated when backward pressure was made on the left globe with the ball of the thumb applied to the closed eyelids; the resistance was not unyielding and suggested that the globe was supported and pushed forwards by œdematous orbital tissues rather than by any solid growth of new formation. The vision of the affected eye was only perception of light; its pupil was equal to that of the right eye, but the action of the sphincter pupillæ to the direct stimulus of light, though not absent, was very much impaired. The palpebral fissure was normal. There was no loss of cutaneous sensibility over the fifth nerve areas; the patient had experienced no disturbance of smell or of hearing; the knee-jerks were normal. On ophthalmoscopic examination I was able to appreciate that the surface and outline of the left optic

disc were less clear than the corresponding features of the papilla in the fellow eye. I ordered her to wean her baby, and prescribed three small circum-orbital blisters and Hutchinson's pill.

A week later she had weaned her baby and used the blisters. The prominence of the left eye was still present but had diminished. She informed me that a sensation of stiffness accompanied the movements of the affected eye. The neuralgic pain in the head was relieved. She thought she still had a shade of light in the eye, but I could not on this occasion detect any direct action of the pupil to light. The disc was not of good colour in either eye; in the left, pathological blurring of the edge of the disc was undoubtedly present and more marked at the upper and lower than at either of the lateral margins. The mercurial pill was continued. I did not see the patient again until April 16, 1902, when she came in response to a post card which I had sent her. I learnt that a mercurial stomatitis and diarrhœa had resulted from the Hutchinson's pill and she had consulted a doctor privately. By this date, however, some return of vision had occurred; she had 6-60ths and 16 J.; the pupillary action to light had returned fairly well. Slight proptosis was still present, but no limitation of downward movement now existed; all pain had disappeared. Ophthalmoscopic examination revealed an optic nerve obviously passing into partial atrophy; the papilla was conspicuously pale; the branches of the central artery were normal in size, but beneath most of them there was a faint white haze of œdema, wider and less definite than the lines of connective tissue often seen in the tunica adventitia after neuro-retinitis; this change was particularly marked in relation to the superior and inferior temporal vessels. I prescribed iodide of iron.

I saw the patient again on May 7, 1902. The

condition of the eye was unaltered. I took the field on the perimeter; it was full in all directions except in the lower nasal part, where a sector with its apex reaching to within 20° of the fixation point was lost.

I saw the patient for the last time a month later. The field was again charted and exactly confirmed that recorded on May 7. The direct vision had improved to 6-36ths; I thought I could still appreciate slight prominence of the eyeball. Except for the vision being defective in this eye Mrs. C— considered herself quite well.

### Case 4.

*Retro-bulbar Neuritis; Recovery.*

B. B., female, aged 29, married, was sent to me at St. Thomas's Hospital by her doctor on September 5, 1900.

The history given was, that one week previously she had splashed some boiling water into the right eye; two days later she observed a blurring of sight and on covering her left eye experimentally she found that the vision of the right was very defective.

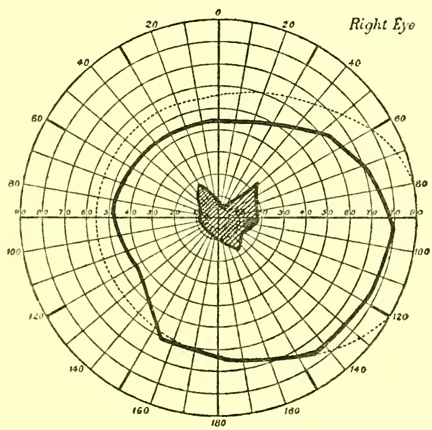
On September 5, the vision of the affected eye was barely 2-60ths; the action of its pupil to direct light was very feeble compared with its response to the indirect stimulus. The left eye had full acuteness. The patient stated that when using the right eye only she saw my face more clearly by looking at one side of it than by directing her eye straight at it. The field for white was taken with a 10 mm. test spot, and is reproduced.

The shaded area in the centre indicates the shape of the central scotoma which was present; it existed for both form and colour, but too much stress should not be laid on its exact measurements, as its borders were

apparently not hard and sharply defined, but faded off in a penumbra-like way.

Ophthalmoscopic examination revealed no difference between the two fundi; each picture was perfectly normal.

The patient complained of some slight tenderness when backward pressure was exerted on the right eye. Her youngest children were twins, aged 4; she had one other child a year older; none of her family had died and she had had no still-births or miscarriages. She stated that at times she experienced mild rheumatic pains in her wrists.




B. B.—September 5, 1900. Field for white. The limits of the field and of the scotoma were investigated with a 10 mm. white spot.

All other investigations proved negative. There was no evidence or history of ear or nose trouble; no carious teeth; no disorder of sensation or tenderness of orbital margin. After a week, during which counter irritation and mercury were employed, there was no change in the condition; but when I saw her on September 19, 1900, she told me some improvement in sight had commenced two days before; she could not yet see 6-60ths, but could detect the presence of a black mark at the top of Snellen's board at a distance of 6 metres. At this date I noted that the

right disc was just appreciably paler than the left. By October 10, the acuteness of vision in the affected eye was 6-60ths and she saw shadows of the letters in the next line of the test types.

On November 21, 1900, the vision of the right eye was 6-12ths, and she could read 6 J. There was now no doubt whatever about the pathological pallor of the right optic papilla ; in spite of this I think it probable that still further recovery ensued, but I did not again see the patient.

### Case 5.

*Ocular Symptoms in Disseminated Sclerosis.*

E. W., female, single, aged 21, saw me on January 8, 1902. In the previous autumn she had experienced symptoms of giddiness, shaking of head, and intention tremor of limbs ; she had also had difficulty in the pronunciation of words and during six weeks had suffered from diplopia ; I learnt that while lying in bed she had seen through the window eight chimney pots, four of which appeared to be higher than the other four ; the diplopia was therefore vertical ; when it disappeared she discovered that the total number of chimney pots was only four. By the time I saw E. W. her general symptoms had greatly improved. I learnt from her that she had had a similar illness six years before.

On January 1, 1902, the lids were inclined to droop and the eyes to ache of an evening ; there was no complaint of defective sight, and each eye had an unaided acuteness of 6-6ths, the refraction being low hypermetropia. The fields were taken, but in artificial light ; she had never been examined with the perimeter before ; the charts showed a peripheral loss varying between 10° and 20° in the whole circumference ; I believe this may

be explained by the bad illumination and by inexperience of the test on the part of the patient.

The eyes showed slight but definite pathological nystagmus when they were laterally directed ; the jerks were less conspicuous when the eyes were elevated, and when they were depressed were hardly noticeable. The left pupil was just appreciably smaller than the right. Both acted normally to light and on convergence. At times the left palpebral fissure was slightly narrower than the right, but this was not constant. The optic discs were distinctly pale—a point of great importance in diagnosing cases of insular sclerosis from functional disease ; at the time I saw her no central scotoma existed ; this feature may have been present a few months earlier ; it is often transitory. There were no other changes in the fundi.

The knee-jerks were obtained very readily on the slightest tap being given to the patellar tendons, but the excursion of the movement produced was not very excessive.

## Case 6.

*Ocular Symptoms in Disseminated Sclerosis.*

Miss L., aged 23, consulted me privately on March 14, 1901. She gave me a history that in the previous August she had been thrown out of a trap when driving ; she was insensible for five hours, and suffered from concussion followed by vomiting. She remained in bed for only one week, and then, treating the whole accident with undue levity, was up and about again, feeling well and following her usual routine of life. For the three months before I saw her she had been noticing an apparent shimmering of objects, and distant objects had appeared double when she looked to the right side, but not when the gaze was directed to the left. At Christmas, 1900, she had suffered

from what she called a bilious attack of quite unusual severity ; she remained in bed for a fortnight, and her doctor was in attendance. At the time she came to me she said she felt well in general health, but was troubled by the visual disturbance and by headaches.

V. of each eye was 5-6ths or c̄—0·75 D. 5-5ths. The fundi and pupils showed nothing abnormal. There was some slight nystagmic movement of the eyes. When the eyes were lateralised to the right there was homonymous diplopia; tested with a candle flame at about six feet, the greatest interval between the images was about five inches, and was corrected by a $5^{\circ}$ prism.

The movements of the tongue and palate and the sense of hearing were unaffected. My recollection is, but I have no note of it, that just occasionally Miss L. had the slightest hesitation in pronouncing a word ; it was so slight that neither she nor her friends had recognised it.

The knee-jerks were excessive.

On my advice she took a small dose of Easton's syrup ; gave up all work ; avoided all amusement and excitements; endeavoured to give complete rest to eyes and brain, and saw a physician in consultation with me a fortnight later. My colleague agreed with me as to the diagnosis, and looked upon "the bilious attack" at Christmas as a part of the central nerve disease ; he regarded the insular sclerosis as having been originated by the concussion in the previous August ; and thought that sclerotic patches following disseminated petechial hæmorrhages might perhaps not be progressive. About eighteen months later the patient came under careful observation in a hospital, and from the notes taken I have learnt the following additional particulars : The symptoms present when I saw her had all persisted, and for some months she had been unable to stand or walk without support ; there was no spasticity or inco-ordination of limbs ; at the close of her stay in hos-

pital she was able to walk slightly but adducted the foot she advanced, so that it was planted on the ground in the line of the one behind. There was slight tremor of the movements of the upper limbs, and also in the orbicularis oris muscle ; in exposing the teeth she drew up the left side of the mouth rather more than the right side ; the tendon reflexes were not regarded as typical of anything, but the left patellar jerk was more free than the right, and an extensor plantar reflex was obtained in the left foot only. The nystagmic movements of eyes, the diplopia and healthy fundi were maintained unaltered from the time I had seen her. The diagnosis of disseminated sclerosis was considered at the hospital, but the possibility that the whole of the symptoms were functional was also entertained.

## Case 7.

*Ocular Symptoms in Disseminated Sclerosis.*

W. S., male, aged 38 years, 'bus-driver, was an in-patient of St. Thomas's Hospital under one of my colleagues from November 21, 1901, to January 8, 1902. He attributed his symptoms to a mental shock he had experienced in an accident four years before. Shortly after the accident, in which he suffered no physical injury, he found that his left leg began to drag, particularly when walking briskly ; he became awkward in steering his course among pedestrians, and was apt to collide with people ; he found it difficult to climb to and from his box on the omnibus. Eighteen months before his admission, when walking across an open common, he had staggered and reeled like a drunken man, and was stared at as such by the bystanders; since this date he had at intervals suffered from attacks of giddiness ; for some months he had found it difficult to turn when in bed ; and his legs had been stiff in the early

morning, so much so that lately for an hour or so after rising from bed he had found it impossible to stand.

There was no family history of nerve disease, and the patient denied venereal disease or abuse of alcohol.

In the hospital the following observations were made:—

Slight asymmetry of face due to loss of skin wrinkles and power of facial muscles on the left side. No loss of sensation over the fifth nerve areas.

*Eyes.*—Fields of vision, taken on the perimeter, were normal. The pupils were equal and acted well both to light and on convergence. The optic discs were pale and showed conspicuous physiological cups. There appeared to be weakness of both internal recti, and the left eye occasionally moved outwards independently of its fellow.

*Arms* were normal as regards movement and sensation. No intention tremor.

*Legs.*—The left leg was weaker than the right. Sensation both for touch and temperature unimpaired.

The tendon reflexes at the elbows, wrists and knees were all brisk ; the patellar jerk was more exaggerated in the left than in the right leg ; Babinski's extensor plantar reflex was present on both sides. No clonus.

The gait was deliberate and a little uncertain, but there was no swaying when it was tested.

There was no Romberg's sign or loss of muscular sense.

His skin showed a peculiar rough and scaly appearance on the trunk and shins. In his speech he had always had a lisp ; in addition to this there was now a slow scanning articulation, which his friends had observed during the previous six months.

A diagnosis of a lesion in the region of the corpora quadrigemina was thought possible, and I was asked to see the patient, and did so on November 26, 1901, when I made the following note :—

"The pupils are equal and act to light both directly

and indirectly, and also with convergence, a movement he is quite able to carry out ; there is no hemiopic pupillary phenomenon.

"Ocular movements. There is distinct nystagmus, especially in extreme positions of the eyes. The internal recti are not paralysed, but the inward movement of either eye is imperfectly performed and maintained; no limitation of vertical movements ; no ptosis. Fields full. Vision appears full ; I tested him with the small type in the calendar of a Prayer Book which happened to be handy ; he at once read there 'St. Thomas's Hospital,' the day marked being really 'St. Thomas, Apostle.' Optic discs are distinctly pale, especially in their temporal halves which show a little shelving excavation, the lamina cribrosa of each being conspicuously exposed.

"The long duration of the ataxic symptoms with so little affection of the ocular muscles, no vertical movement being impaired, the nystagmus, pale discs and absence of any pupillary affection, make me favour a diagnosis of insular sclerosis rather than of lesion of the corpora quadrigemina."

Further observation of the patient confirmed my opinion of the case. There was no marked change or development in his symptoms ; he had varying degrees of vertigo, reeling gait and stiffness of back and limbs ; the nystagmus varied in intensity ; from time to time vertical headache was complained of. At the end of December he had an attack of swelling of the right hand and wrist, with rise of temperature to 102° F. ; there was loss of power in the hand, with complete recovery in three days ; it was immediately followed by a similar attack implicating the right ankle which subsided in an equally rapid way. On the whole some amelioration in his condition took place in the hospital, from which he was discharged on January 8, 1902.

## Case 8.

### *Lesion of the Corpora Quadrigemina.*

S. A. M., male, aged 18, an electrician, was admitted under one of my colleagues at St. Thomas's Hospital, on September 18, 1900, and died on December 26, 1900. For ten days prior to his admission he had been suffering from severe headache in the frontal and occipital regions, accompanied by attacks of vomiting at its onset; he had had several falls, owing to the knees giving way, and his legs had occasionally been so unsteady that he had required support in walking home from work. He stated that the eyes had been weak for eighteen months, objects appearing blurred, and that the vision had grown much worse since the onset of the headaches.

On admission there was no impairment of the olfactory nerves. Double optic neuritis with hæmorrhages was observed. Associated upward movement of the eyes was completely absent; abduction of each eye was imperfect, the weakness being more conspicuous in the left. The pupils were dilated, and were said to react to light sluggishly but more briskly with convergence.

There was no nystagmus or ptosis.

The 5th, 7th, 8th, 9th, 10th, 11th and 12th cranial nerves were all normal in function.

The knee-jerks were absent. There were no increased reflexes.

The urine was normal.

A week later the condition of eyes and knee-jerks was as before. It was observed that the pupils contracted when the observer resisted attempts on the part of the patient to close the lids with the orbicularis palpebrarum muscles. The grip of the right hand was found to be weaker than that of the left. The patient had been vomiting at intervals.

A few days later the weakness of the right upper extremity was more marked, and homonymous diplopia was recognised in each lateral half of the fixation field.

By October 9, 1900, tremor of lips and tongue had developed, accompanied by some hesitation and jerkiness of speech. Headache and vomiting continued. The temperature was persistently subnormal, the pulse not unusually slow. A week later both knee-jerks were found to be present, that on the right side being quite brisk; the left leg had considerable loss of power and the right was weak. The pupils were equal and the ocular movements as before.

On October 18, 1900, I saw the patient, by request of my colleague, and made the following notes on the condition of the pupils: "They react with convergence better than to light, but the pupils do act to light, though sluggishly, and with a tendency to again dilate. I fancy if the light is concentrated on the left halves of the retinæ a better reaction is obtained than if it is concentrated on the right halves, *i.e.*, he shows, not too well, the hemiopic pupil; however, tested with a candle flame, there is no hemiopia as regards fields of vision. If these observations are correct they localise a lesion on the right side between the primary optic ganglia and the third nerve nucleus." The patient was already difficult to rouse at the time I saw him; he gradually became more dull and apathetic; occasionally complained of headache, and suffered from vomiting; one or two attacks were observed in which his trunk and limbs became rigid, the jaws clenched, and the pupils widely dilated. Loss of control over rectum and bladder developed. The knee-jerks were not again lost. The pupils were repeatedly noted to act to light, and were at times unequal, the right being almost constantly larger than the left. Constipation eventually developed, the patient

became wasted and listless and died on December 26, 1900.

The autopsy was made twenty-two hours after death.

On removal of the skull cap and dura mater a considerable quantity of cerebro-spinal fluid escaped both from the base and the great longitudinal fissure; the corpus callosum was very soft, diffluent, and evidently in great part destroyed. At the base the floor of the third ventricle was much thinned and reduced to a translucent membrane; the optic tracts would probably have been subjected to considerable pressure during life.

The brain was hardened in formalin and further examined.

The entire ventricular system was greatly distended, and the ependymal layer softened and roughened. The choroid plexuses were also ragged and softened. The fourth ventricle was dilated and its floor had a granular, soft appearance; the lateral foramina opening into the sub-arachnoid space could not be found. The anterior projecting portion of the corpora quadrigemina was particularly ragged and softened. The whole condition conveyed the impression of a primary inflammation of the ependyma at the posterior end of the ventricular system with blocking of the foramina of communication and secondary dilatation of the ventricles as the result.

A portion of the corpora quadrigemina was reserved for microscopical examination and proved the presence of malignant growth. My colleague informed me that the lamina quadrigemina was thickened and œdematous and on cutting it he was surprised to find it the subject of sarcomatous infiltration; the growth was diffused and ill-limited and he was unable to say whether it involved one side more than the other.

The early onset of visual symptoms and ocular paralyses associated with unsteadiness of gait is to be noted in this

case. Had vertigo and implication of the nuclei of the posterior of the cranial nerves been the early symptoms that were found associated with the more general signs of intra-cranial tumour, the middle lobe of the cerebellum would have been the more probable seat of its growth. The diagnosis of the site of the lesion between these two positions is particularly difficult, and neurologists are not in universal agreement as to the localising value of the different symptoms and their order of onset: there is, however, a general consensus of opinion that vertical diplopia associated with limitation of ocular movements in the vertical plane is indicative of a lesion of the anterior corpora quadrigemina. The presence of the hemiopic pupil in the absence of hemiopic fields in S. A. M.'s case confirmed the locality of the tumour; the lesion, at the time the observation was made, was involving on the right side the pupillary fibres passing to the anterior part of the third nerve nuclei, after these afferent fibres had dissociated themselves from the visual fibres which they had accompanied in the right optic tract; had the corresponding fibres from the other tract been involved in the symmetrical situation the pupils would have presented the Argyll-Robertson phenomenon. Swanzy admits the possibility of the hemiopic pupil without hemiopia, but says no such case has been recorded. My observation on this case was made and noted more than two months before the death of the patient; microscopical examination of the tissue obtained at the *post-mortem* examination unexpectedly proved the presence of a tumour in the situation required to explain the phenomenon. The facts that the pupils were usually unequal and in the later stages of the case the right constantly larger than the left indicate that the lesion was implicating the nerve paths and the third nerve nucleus more extensively on the right than on the left side, and this agrees with the difficulty experienced

in obtaining a pupillary light reflex when the illumination was concentrated on the right half of either retina.

## Case 9.

### *Lesion of the Corpora Quadrigemina.*

E. G., female, aged 21, single, consulted me privately in the middle of August, 1901. She had suffered from rheumatic fever twice and also from chorea, but her doctor informed me there was no valvular disease of heart, and no family history of tubercle. There was nothing to suggest congenital syphilis. Her parents have three younger children who are deaf-mutes.

The history was that she was called to rise from bed in the morning and felt giddy; noticed that she saw double and then fell on the bed unconscious. She was found in this condition an hour or so later and remained insensible for three or four days. The doctor was summoned and fancied the condition must be functional; he was unable to detect any paralytic symptoms. She was kept in bed for a week and saw me a fortnight later. At this time she was still inclined to be heavy and drowsy, and complained of double vision when both eyes were open. She could see well with either eye alone and preferred to close the left and use the right.

I found the left eye to be depressed and an appreciable degree of convergence was also present, but this was slight; there was no restriction of its lateral excursion in either direction. Although this eye when at rest occupied a lower level than its fellow, the voluntary movement of depression was impaired, and its elevation could be very imperfectly performed; at first sight there appeared to be some ptosis, but this was not really so, and the drooping of the upper lid was only proportionate to the altered primary

position of the eyeball. There was some nystagmic movement in each eye, worse in the left eye than in the right, and especially well seen when fixing in the left half of the field. The left pupil acted normally.

Apart from slight nystagmus the extra-ocular muscles of the right eye acted normally ; in curious contrast, the right pupil was as a rule larger than the left, and showed very little contraction to the direct stimulus of light, while it was doubtful if it acted at all when convergence was made.

There was no evidence of the hemiopic pupil for which I carefully examined. The patient could read 1 J., and her power of accommodation was unimpaired in either eye. The fundi were normal.

The knee-jerks were normal ; there was no clonus. The seventh and twelfth cranial nerves acted well.

On November 30, 1901, I saw her again and she was evidently much better. She still covered the left eye, but was by now less confused than formerly when both were in use ; "she did not now see double when lying on the back," *i.e.*, with the eyes depressed. There was still some loss of power of elevation of the left eye and its upper lid still showed a droop. The patient had vertical diplopia, and the image of the left eye as well as being above that of the right was inclined to tilt away from it at its upper end. The pupils were now equal and each acted both to light and on convergence, but the right was less brisk than its fellow. Ophthalmoscopically all was normal. The fields to the hand test were full. There was no evidence of any orbital trouble. No loss of sensation anywhere ; no weakness in the grasp of either hand.

The patient eventually completely recovered without anything further to throw light on the diagnosis.

From its sudden onset I have no doubt that the lesion was a vascular one of very limited degree which affected

the forepart of the iter and the quadrigeminal region; the age of the patient and the history of chorea and two attacks of acute rheumatism forcibly suggest a minute embolus, even though auscultation could detect nothing amiss in the cardiac sounds. There were no svmptoms pointing to cerebral growth, and a small hæmorrhage seems very improbable.

A strikingly similar case in a young woman, aged 25, is recorded by Adams Frost in vol. v. of the *Trans. Ophth. Society*, p. 197, and another case was reported by Snell to the same Society in the Session of 1902-3, and is recorded in vol. xxiii. of its *Transactions*; Snell's patient was a man past middle life and a hæmorrhage was perhaps a more probable cause of the trouble.

The following references to further cases of tumour or hæmorrhage in this situation may be found of service:—

Gowers, *Trans. Ophth. Society*, vol. i., p. 117.
Lang and Fitzgerald, *Trans. Ophth. Society*, vol. ii., p. 230.
Ormerod, *Trans. Ophth. Society*, vol. iv., p. 310.
Nothnagel, *Brain*, vol. xii.
Ferrier, *Brain*, vol. v., p. 123.
Bristowe, *Brain*, vol. vi., p. 167.
Sharkey, *Brain*, vol. xvii., p. 238.

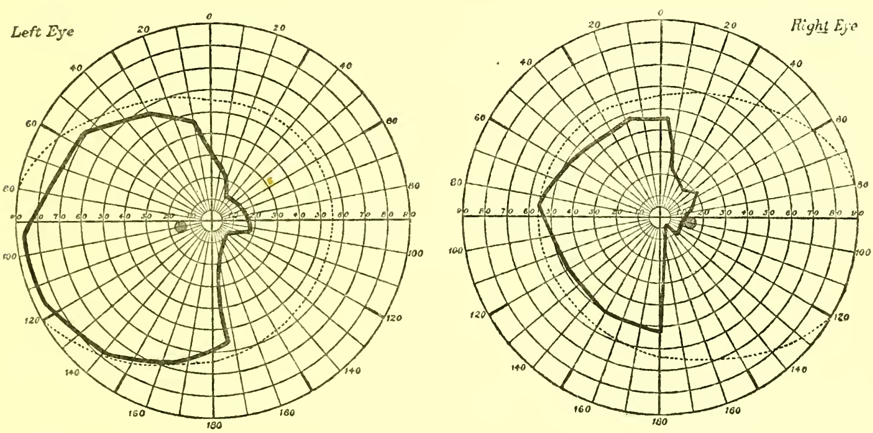
## Case 10.

### *Bullet Wound involving Cortical Centre for Vision.*

W. S., formerly of the Grenadier Guards, saw me on November 23, 1900. At the battle of Belmont, on November 23, 1899, he received a bullet wound at the back of the head. He was rendered unconscious and remained so for five days; during this interval he had been operated upon by Mr. Makins, who kindly sent him and the two succeeding cases to me.* At the operation

* I examined and reported on these three cases for my colleague and from the point of view of military surgery they are briefly described in his book entitled "Surgical Experiences in South Africa."

the depressed bone of a gutter fracture was elevated and removed; the dura mater was found to have been opened and lacerated by the bullet; much brain matter came away at the time of operation and subsequently. On recovering consciousness W. S. found that he had no perception of light, and was unable to speak to anyone; the pupils during the period of blindness were recorded as large, but responsive to light. He recovered vision gradually; in a day or two after recovering his senses light began to come back "like day dawning," and a fortnight later he was able to read a word or two.




W. S.—Fields for white, spot 10 mm. Taken in good daylight, November 23, 1900, by J. H. Fisher. Bullet-wound of occipital region twelve months previously.

When I saw him twelve months after the date of his wound he thought the vision of one eye was as good as that of the other, but he was aware of inability to see on his right-hand side and was apt to collide with obstacles on this hand.

I found V. of R. $\frac{5}{12}$ $\bar{c}$ — 0·5 D. S. = $\frac{5}{6}$.

V. of L. $\frac{5}{9}$ $\bar{c}$ — 0·5 D. S. = $\frac{5}{5}$ well.

In neither eye, however, was he really myopic.

The pupils were equal and acted well to light, and did not show the hemiopic phenomenon. The movements of

the eyes were quite normal; there was no diplopia, and he informed me he had no difficulty in recognising colours.

The fields were taken and show characteristic right homonymous hemiopia; his answers to the perimeter test were quite ready and given with military precision. The hemiopia could be at once recognised also by the rougher hand test.

I found that W. S. presented a broad straight linear scar in the scalp, so tender to the touch that he could scarcely bear to wear the uniform cap of the Corps of Commissionaires in which he was serving at the time he saw me; the scar began over the occipital bone about one inch to the left of the middle line at a level corresponding with the external occipital protuberance; it measured about $2\frac{1}{2}$ inches long and ran upwards and to the right to terminate over the upper part of the occipital table on the right side close to the lambdoid suture; beneath this scar the bone could be felt to be defective, and cerebral pulsation was imparted to the soft tissues of the scalp.

At the time I saw him recovery of speech was still not quite perfect; his difficulty, however, was very slight and appeared to me to be one of articulation; I did not consider W. S. to illustrate the not very uncommon association of right cortical hemianopia and word-blindness.

The symptoms and site of fracture of skull correspond well with a lesion of the left occipital cortex in its cuneate lobe, and in the neighbourhood of the calcarine fissure; a cortical or sub-cortical lesion is supported by the observation made on the patient that during the period of complete abolition of vision the pupils responded well to the light stimulus.

## Case II.

*Bullet Wound involving Cortical Centres for Vision.*

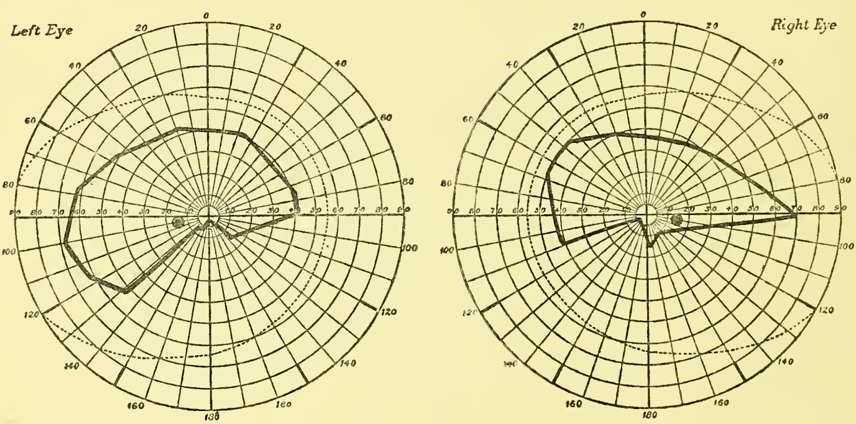
Pte. W., aged 26, of the 2nd Seaforth Highlanders, was wounded at a range of about 1,000 yards by a Mauser bullet, on May 25, 1900. He was said to have been quite blind when brought in; the pupils were reported to have been equal and of moderate size; he remained in a semi-conscious condition for five days, and on coming to himself "all was dark"; six days later he first recovered perception of light. He was sent to me on December 8, 1900; by this time gradual improvement in his sight had taken place to a considerable degree, but he was unable to recognise that any further progress was being made.

He had, when first examined, right hemiplegia and right facial paralysis; there was never any aphasia. No operations had been performed.

At the time I examined him his head presented the scars of two independent injuries to the skull. One was a small depressed wound, the size of the tip of the little finger; to the soft tissues of the scalp pulsation was imparted, the bone being deficient—this scar was situated just above the line of the right lateral sinus, *i.e.*, above the tentorium cerebelli, about half-way between the external occipital protuberance and a line drawn vertically through the right external auditory meatus. The other scar corresponded to a gutter depressed fracture by which the upper part of the left parietal bone had been much comminuted; the scar was about $3\frac{1}{2}$ inches in length; began in the sagittal suture about $1\frac{1}{2}$ inches in front of the lambda and ran a curved course, bowed outwards, to terminate in a line drawn vertically through the left external auditory meatus at a distance of nearly 2 inches from the sagittal suture; I detected no pulsation at the site of this fracture. Neither scar was tender.

At the time I saw him considerable recovery of power in the right leg had occurred, but the foot dragged ; the right arm remained very weak, and there was some blunting of sensation in the finger-tips; the right facial paralysis had almost entirely passed off; with the right ear he was quite unable to hear a watch ticking, but said he felt it ticking when it was held in contact with the pinna.

The patient had no aphasia. The fundi, pupils and movements of the eyes were all normal. He told me he was unable to see below a certain horizontal level, so that he had constantly to be turning the eyes to the ground




Pte. W.—Fields for white, spot 10 mm. Taken in good artificial light, December 8, 1900, by J. H. Fisher. Bullet wound of occipital region, May 25, 1900.

when walking; he demonstrated this defect in his visual fields with his hand to me quite intelligently. The fields taken on the perimeter will be seen to accurately agree with his statements: they are typical of altitudinal hemianopia.

I conclude that the occipital lesion accounts for the visual defect, while the injury to the left Rolandic convolutions explains the hemiplegia and possibly also the facial paresis; the left-sided damage might, however, be involving the posterior limb of the internal capsule as well

as the cortex. The deafness was probably not central; my colleague, Mr. Makins, found that all patients in whom a bullet had traversed the mastoid region were left absolutely deaf, and he attributed the deafness to concussion of the internal ear; probably this is the correct explanation in the case of Pte. W., and it makes one suspect that the right facial nerve was implicated in its passage through the petrous bone from the internal auditory meatus to the stylo-mastoid foramen. Mr. Makins considers that the bullet entered at the occiput (the patient preferred to regard the more anterior wound as the aperture of entrance), and that it must have involved a considerable extent of the outer aspect of the right occipital lobe, possibly also the hinder end of the right temporo-sphenoidal lobe, and certainly the cuneate lobule; it must have crossed the great longitudinal fissure and penetrated the left Rolandic convolutions just above the centre of the Rolandic fissure.

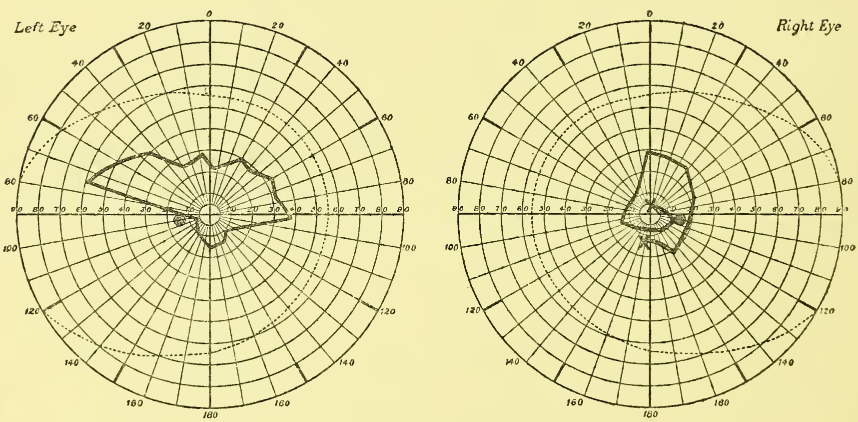
## Case 12.

### *Bullet Wound involving Cortical Centres for Vision.*

J. W. R., aged 21, received a bullet wound of the head at Magersfontein at 500 yards range on December 11, 1899, and was sent to me on December 1, 1900; Mr. G. H. Makins saw the patient soon after his wound, and thought the bullet had not perforated but had grazed the occiput, causing a depressed fracture in this region; an operation to elevate the depressed bone was performed under his direction, and a week later renewed symptoms of cerebral irritation called for a further operation when more bone was removed, some fragments being found driven in to a depth of two inches from the surface. Both operations were performed at Orange River; he was in

hospital at Wynberg till January 31, 1900, and reached home four weeks later.

When I saw him twelve months after the wound he told me he was blind for two days after being shot, and that the sight gradually returned; he complained that it was still defective so that he was apt to collide with pedestrians, had been nearly knocked down by a vehicle in Glasgow and was accused by his friends of passing them without recognition in the street. He had been seen by an ophthalmic surgeon who had certified that




J. W. R.—Fields for white, spot 10 mm. Taken in good artificial light, December 1, 1900, by J. H. Fisher. Bullet wound of occipital region, December 11, 1899.

his vision incapacitated him from further service in the Argyll and Sutherland Highlanders, and he seemed well pleased with the position he had obtained as an assistant postman; at first he appeared to view my motives with suspicion and repeatedly insisted on the fact that he had been certified as unfit on account of vision. On gaining his confidence, however, I found that the vision of either right or left $\bar{c}$ + 3·0 D. sph. was 5-6ths and binocularly with these lenses he read 5-5ths partly. He volunteered the statement that when he looked at me with the left

eye he saw the upper but not the lower part of my face. The fields were taken on the perimeter and are here reproduced. That of the left eye was first charted and is definite and reliable in showing the lower half of the field to be lost, though the seeing portion may perhaps be smaller than it really should be. The right chart is typical of the spiral functional field, and this feature of it obscures all else; the lower half of the field may or may not be lost; he did not say he was aware of an altitudinal deficiency in the right eye. I observed that he was able to guide himself in my consulting room without difficulty or mistake, and I watched him walk away briskly and without hesitation from my front door on a dull afternoon. He told me he felt no anxiety about getting about London, with which he was quite unfamiliar, and I came to the conclusion that the visual field of the right eye must undoubtedly be bigger than the chart indicates.

The fundi were quite normal; the pupils equal, active and normal in every way. By estimation I found he had in each eye a hypermetropia of 6·0 D.; when he enlisted at the age of 14, as a drummer boy, his refraction was, of course, not measured, merely the acuteness of vision tested.

I found that he had a lozenge-shaped area of loss of bone at the apex of the occipital table; each side of the lozenge measured about five-eighths of an inch; the depressed area extended on both sides of the mid-line, but reached rather farther to the right than to the left.

On Henschen's view that the upper parts of the occipital visual centres represent the upper dorsal retinal quadrants, the lower parts the lower quadrants, and the bottom of the calcarine fissures the maculæ, J. W. R.'s state is explicable, if we assume that the lower half of the right field was lost, which may quite probably be the case. The patient has a bone lesion at the lambda so that it

would be likely to be accompanied by damage to both cuneate lobes above the calcarine fissures, while the lower parts of the visual centres would have a good chance of escaping injury; the fracture being fairly median in position, and, having been produced by a non-perforating bullet, might be expected to damage both half vision centres in their upper portions. Marcus Gunn, in his Bowman lecture, acquiesced in Henschen's delimitation of the visual cortex.

## Case 13.

*Bullet Wound indirectly involving Cortical Centre for Vision.*

A. C., aged 29, was sent to me on July 8, 1901 ; he had been shot at the battle of Pieter's Hill, in February, 1900, probably with a Mauser bullet. He was rendered unconscious, but recovered his senses in about seventy-two hours, when he observed no visual defect ; a trephining operation had been performed.

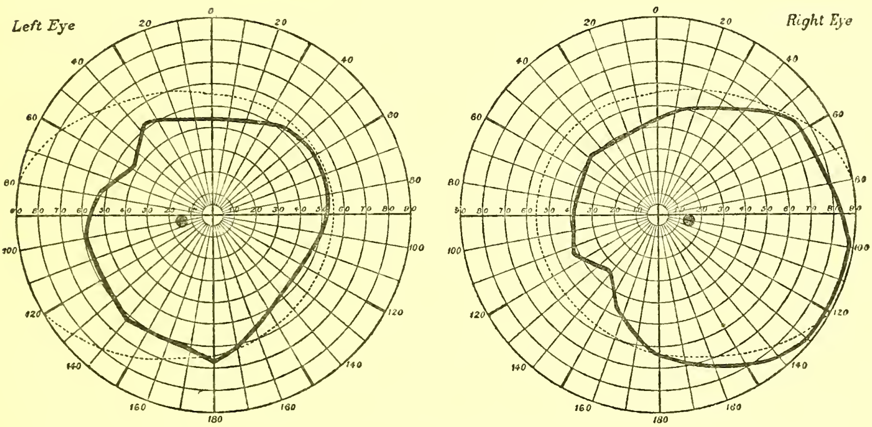
The entrance wound of the bullet I could still feel over the upper end of the Rolandic fissure just to the right of the mid-line ; a larger depressed fracture situated midway between the external occipital protuberance and the right external auditory meatus, but rather above this line and close to the lateral angle of the occipital table, indicated the exit wound. At the time I saw him there was great weakness of the left leg and arm, and the grasp of the right hand was enfeebled. There was no deafness.

V. R. $\frac{6}{24}$ $\bar{c}$ — 2·0 D. sph. = $\frac{6}{6}$ fairly.
L. V. $\frac{6}{36}$ $\bar{c}$ — 2·0 D. sph. = $\frac{6}{12}$.

The vision of the left eye I failed to improve further. The fundi were quite healthy. The right pupil measured $3\frac{1}{2}$ mm. ; the left being only 3 mm. Each acted to

light, but the contraction of the right pupil was not quite so complete or so well maintained as that of its fellow.

The fields taken with the perimeter and here reproduced show a distinct loss in the left periphery of each, *i.e.*, a characteristic indication of, but not a complete left lateral hemianopia. The fields are quite reliable ; the patient being a very satisfactory man to test and quite accurate in his replies.




A. C.—Fields for white test, spot 10 mm. Taken in good daylight, July 8, 1901.

I consider the partial hemianopia to indicate an indirect damage done to the right cuneus ; the bullet obviously did not pass through the right half vision centre, but it may easily have produced some disturbance of it ; this patient was unaware of any affection of his sight, and it is important to note that he never lost vision as far as he was aware ; each of the three preceding patients, whose visual centres presumably were directly injured, lost all sight and found everything dark when he recovered consciousness—a symptom which, in each case, persisted for a considerable period.

## Case 14.

*Homonymous Hemiopia, of Central Origin, probably due to Arterial Obstruction.*

G. J. B., male, aged 55, attended under me at the Royal London Ophthalmic Hospital on September 17, 1902. He complained of failure of the right eye, which proved to mean that he had lost sight on his right-hand side. He discovered it, apparently suddenly, one afternoon about two months before coming to the hospital; the onset was accompanied by an attack of vertigo and vomiting, for which he kept his bed one day only; the sickness ceased, but on each of the next two or three days he experienced one or two attacks of giddiness; for some years he had been liable to slight frontal headaches. There was no history pointing to renal mischief, but I find I have no note that an examination of the urine was made.

R. V. = $\frac{6}{6}$ h.m. 1·0 D. L. V. = $\frac{6}{6}$ h.m. 0·75 D.

Fundi quite normal; arteries of the retinæ appeared healthy.

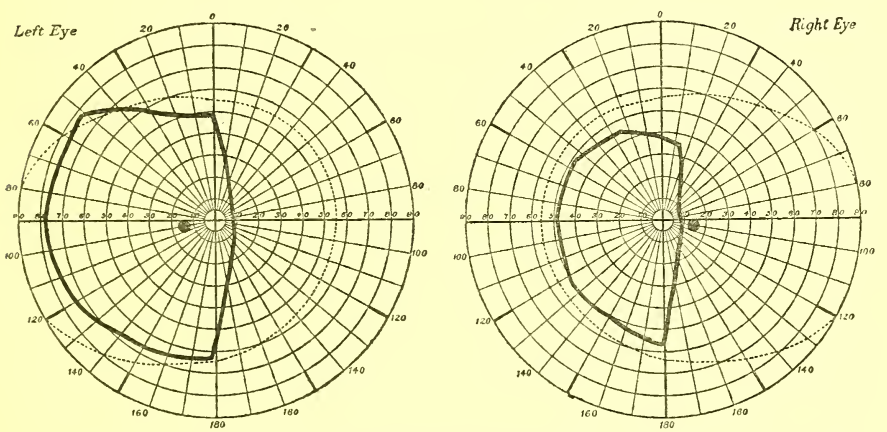
The pupils were equal and acted normally, and gave no sign of the hemiopic phenomenon.

Holmgren's test revealed no defect of colour vision. He stated that he could read quite well with his spectacles. There was no loss of memory. The knee-jerks were normal. There were no cardiac murmurs. The radial arteries did not seem unusually degenerate for a man of his years.

The fields show a characteristic right homonymous hemiopia; it will be observed that in each the macula is included in the seeing half of the retina, so that direct vision was unimpaired.

A fortnight later I again saw the patient. No further symptoms had developed. During the preceding week he had experienced only one slight attack of vertigo, which did not last longer than a minute or two.

At the beginning of November he had suffered from giddiness for a whole week; during this week he rose from bed without it, but on each morning it soon asserted itself and persisted throughout the day; his work, as a chair-maker, involved a good deal of stooping, but the vertigo did not seem to the patient to be influenced by posture. On November 15, 1902, he told me he thought his hearing on the left side had, during the preceding fortnight, been a little dull compared with that on the right side, but on testing him with a watch I could obtain no confirmation of this observation; the watch was heard quite well with the left ear and equally well on either




G. J. B.—Fields for white, September 17, 1902. Taken in good daylight.

side; he had never had any ear trouble. Vertigo had been absent for one week; he had had no vomiting during the time he had been under my care. He had never experienced any repeating subjective visual sensations in the blind halves of the fields; it has been suggested that such "processions" are met with in sub-cortical lesions and not in true cortical affections. My colleague, Mr. Marcus Gunn, quotes a case of a horsey man with hemiopia who experienced the sensation of a series of horses' heads following one another in the blind halves of

his fields, but the picture of their bodies and tails was never completed. A further ophthalmoscopic examination was made on November 15, 1902: no fundus changes existed. The patient came from the country and did not attend further at the hospital until May 30, 1903, when he came in response to my written request. Absolutely no new symptom had developed, and no modification of any of the old ones had taken place. The fundi were examined, the pupils tested and the fields charted with results identical with those previously obtained.

The localising signs in this case are conspicuous by their absence. Taking into consideration the absence of pupillary phenomena and of any evidence of involvement of structures at the base of the brain, I am of opinion that the non-progressive symptoms are best explained in a man of this patient's age by obstruction of the calcarine artery of the left side. According to Head, right-sided hemianopia may or may not be associated with one or other or with both forms of sensory aphasia (word-blindness or word-deafness); if such symptoms co-exist they show implication of the gray cortex of the angular gyrus, or of the first temporal convolution, or of both.

## Case 15.

*Paresis of Left Sympathetic Nerve from a Cervical Lesion, accompanied by Paralysis of Third, Fifth, and Sixth, and Paresis of Seventh, Eighth, Eleventh, and Twelfth Cranial Nerves all on the Left Side.*

E. H., female, aged 27, married, was seen by me as an out-patient at St. Thomas's Hospital on September 29, 1897. She complained of attacks of severe frontal headache during the last nine months; the attacks lasted as a rule several days and were so severe that she was

compelled to remain in bed—the intervals between the attacks were as a rule about a week or two weeks in duration. The headaches were never accompanied by vomiting. Two months before I saw her she began to suffer from giddiness and to see double, and she had recently been experiencing pain of neuralgic character in the lower jaw. The upper lid of the left eye she had noticed to droop; the onset of this ptosis occurred only one week before I saw her; it coincided with the appearance of a lump on the left side of the neck, and was subsequent to the onset of diplopia by many weeks.

On examination I found a slight ptosis of the left lid, which drooped as low as the upper margin of the pupil; the patient possessed no power of abduction of the left eye; a movement of adduction could just be appreciated; the range of elevation was about equal to that of depression, but both movements were very limited and imperfect; the movements in the vertical plane were not accompanied by any appreciable wheel-like rotation of the globe. There was no proptosis; no pain or resistance was elicited by making backward pressure on the eyeball through the closed lids.

R. V. = $\frac{6}{6}$; movements all normal. Pupil measured $3\frac{1}{2}$ mm.

L. V. = $\frac{6}{6}$; and reads 1 J. at 10″. Pupil, less than right, measured $2\frac{1}{2}$ mm.

The case, therefore, presented the appearance as far as the eyes were concerned of an ophthalmoplegia on the left side, the third nerve being one of those involved, in which the ciliary muscle retained its power and the pupil so far from being dilated was smaller than its fellow. The ptosis was only partial. The paralysis of the third nerve involved then only its extra-ocular portion; the sixth nerve was paralysed; the fourth probably. The condition of pupil and probably the ptosis were found to

be due to implication of the left cervical sympathetic cord. The ptosis, at any rate, coincided in date with the appearance of a large hard glandular mass under cover of the upper end of the left sterno-mastoid muscle; I was at first inclined to regard this as evidence of malignant disease, but I discovered she had pediculi capitis, and she gave a history that from time to time such swellings appeared and subsided.

I used cocaine equally to the two eyes. It produced no effect on the size of the left pupil and no elevation of its drooped lid; in the right eye the pupil enlarged to $5\frac{1}{2}$ mm., and the upper lid retracted till the sclera was exposed above the edge of the cornea. The patient, when I saw her, was perspiring freely on the right side of her head and face, while the left side was dry.

The temporal and masseter muscles on the right side contracted firmly when she was asked to clench her teeth; the left temporal and masseter muscles hardly acted at all. The left external pterygoid muscle was also inactive so that the lower jaw was protruded to the left side by its fellow muscle. The whole motor portion of the left fifth nerve was therefore paretic; I made out no loss of sensation over the fifth nerve areas; anatomically the buccal branch, from its intimate association with the motor division of the trigeminus, was more likely to be deprived of function than any other sensory nerve; I have no note that I paid special attention to this point, and probably did not do so; unfortunately this interesting patient only attended once, and all my observations had to be made during a single visit in the out-patient room. The left sixth nerve has been seen to be paralysed.

As regards the facial nerve, elevation of the upper lip was less well performed on the left than on the right side. No other evidence of implication of the seventh nerve was noted. The condition of the orbicularis palpe-

brarum muscle might have been specially observed with advantage. As regards the eighth nerve, on the left side the watch was heard at a maximum distance of eight inches; with the right ear she heard it at two feet with ease.

The spinal accessory (eleventh) of the left side was paretic; the left half of the soft palate was imperfectly arched and in phonation the velum was drawn up to the right side.

The left hypoglossal nerve (twelfth) was affected so that the patient could not protrude the tongue straight out of the mouth; it came forwards and to the left side.

The patient had been married seven years; had never been pregnant, and had always enjoyed good health.

The grasp of the hands was equal on the two sides, and the ophthalmoscope showed no change in the fundus of either eye. I prescribed iodide of potassium, and never saw the patient again. I am aware that the notes of the case are incomplete, and a sure diagnosis can hardly be made; the presence of ophthalmoplegia externa and the absence of ophthalmoplegia interna are somewhat in favour of a nuclear lesion, and I am inclined to favour this view of the case; there was no optic papillitis; still it is quite possible to get partial ophthalmoplegia from a nerve trunk lesion, and cases are on record; a basal meningitis or growth must have been very extensive to involve so many nerve trunks, and, had either condition been present, optic neuritis might have been expected; the rigid unilateral character of the symptoms is rather a stumbling block to a series of nuclear degenerations, and the absence of involvement of the motor pathway is somewhat remarkable if the lesion be in the iter and medullary floor. I find I have no record of the senses of taste and smell. Many other points might have been investigated with profit had opportunity offered; the

case as it stands, however, affords a basis for profitable thought and anatomical reflection, and I have considered it worth while to include it in conjunction with the next case I report.

## Case 16.

*Paralysis of Left Third, Fourth, Ophthalmic Division of Fifth, and Sixth Nerves. Optic Papillitis. Neuro-Paralytic Keratitis.*

J. C., male, aged 30, carman, attended at hospital under my care on July 5, 1899. For twelve months he had been seeing double; two months before his visit he had suffered pain over the left side of his head and in the left ear; one month before he came he experienced aching in the left eye, and gradual failure of its vision, accompanied by disappearance of the double sight. His wife first thought the left eye was too prominent a week before he came. He had had no noises in the head or deafness.

There was a history of venereal disease, probably syphilis, seven years previously; he underwent no course of treatment for it. The eldest and youngest of his six children were living and said to be healthy, and were in 1899 aged 10 years and 3 years respectively; of the four intermediate children three died in infancy and one was still-born.

R. V. = $\frac{6}{6}$. No h.m. Fundus normal.

L. V. = Hand shadows. There was complete ptosis and all the extra-ocular muscles were paralysed; the patient had perhaps just an appreciable power of adduction, and it was doubtful if the superior oblique muscle had lost all power. The pupil was widely dilated and inactive. The globe was appreciably proptosed, but perhaps not

more than might be expected as the result of so complete an ophthalmoplegia.

Ophthalmoscopic examination of the left eye showed an active neuro-retinitis ; the superior and temporal edges of the optic disc were very blurred ; the veins were turgid ; there were no hæmorrhages or localised inflammatory exudates to be detected ; the whole of the retina appeared to be œdematous. There was complete anæsthesia over the areas of distribution of the supra-trochlear and supra-orbital nerves ; the sensation of the skin supplied by the nasal nerve and by the second and third divisions of the fifth nerve was normal ; the masseter muscle acted well. The movements of the tongue and velum palati were unimpaired.

I prescribed pot. iod. gr. x., and liq. hydrarg. perchlor. ʒi., to be taken three times a day.

One week later the patient was complaining of less pain over the head ; the ptosis was less complete and power over the upper lid was returning ; it was undoubted that a slight movement of adduction could be effected, but the movements of elevation, depression and abduction were in complete abeyance. Ophthalmoscopically it was recorded that the retinal vessels were tortuous and the veins distended ; that the inferior temporal artery and vein were obscured by some haze ; that the disc was appreciably swollen, and that distinct spots of hæmorrhage were observed below it in the retina. The note made a week later states :—

L. V. = Hand movements. Cannot count fingers. No ptosis now remains. The pupil is still nearly fully wide and quite inactive to both direct and indirect light stimulus. The patient can adduct to-day until the corneal edge reaches the plica semilunaris, and he has slight power both of elevation and depression, but there is no trace of abduction. A further ophthalmoscopic examination was made, and the notes confirm the previous observations

on the fundus changes. Sensation in the left half of the forehead was dulled, but appeared to be recovering.

The patient continued to attend and take the biniodide mixture until August 16, 1899, after which he did not return until September 20, 1899, having had no medicine for a month.

On September 20, he said he had no numbness anywhere. There was no power of abduction of the left eye, but the other movements of the globe had completely recovered. The pupil was still dilated and immobile. The left cornea was now showing a superficial haze, punctate and filamentary in character; this was sufficiently dense to prevent the fundus being clearly seen, but it was made out that the disc was now unduly pale in colour. The biniodide was repeated, but he did not attend again until November 1, 1899. On this day he returned and a definite ulcer in the lower part of the left cornea had developed; a good deal of haze surrounded the area which was actually broken down. The cornea, on testing, was found to be anæsthetic; there was general injection of the globe. The pupil remained wide and quite inactive; no recovery of the sixth nerve had taken place.

The right eye was submitted to careful ophthalmoscopic examination and was in every respect normal, and no syphilitic changes could be detected in it. No examination of the fundus of the left eye could be obtained. A pad and bandage were ordered to be worn over the left eye; hot fomentations to be made and ung. iodoformi cum eserinâ to be used three times a day. The ante-syphilitic treatment was continued.

During the next four weeks, however, the ulceration extended and the base and edges of the ulcer became unhealthy, yellow and infiltrated. Some iritis was probably present at the end of November, but the condition of the iris was by that date difficult to see. On November

29, I substituted ung. iodoformi cum atropinâ for ung. iodoformi cum eserinâ, and, on December 4, I ceased the biniodide mixture and ordered Hutchinson's mercurial pills. By the middle of December I was considering the desirability of suturing the lids to protect the cornea, but the way in which previous symptoms had yielded induced me to hope on. By January 1, 1900, my hopes were justified; the ulcerated area was now less yellow in colour and the cornea becoming vascularised; the ulcer gradually healed leaving a dense nebula, circular in shape and involving two-thirds of the area of the cornea. After taking the mercurial pill for a month, it was noticeable that the left eye was beginning to gain power of abduction, and it soon recovered full movement in this direction. The pills were continued until the end of May, 1900. At this time the left eye had full movement in all directions; the lid was normal and all symptoms that could be tested had completely disappeared; unfortunately the large dense nebula prevented any useful view of the left fundus even with full mydriasis. The right eye was again carefully investigated; it had full vision and no fundus changes.

The lesion in this case was undoubtedly a syphilitic one; all the symptoms, in my opinion, point to an extra-dural trouble, probably a periostitis involving the optic foramen and sphenoidal fissure and the structures they transmit. There were no general symptoms of cerebral disease, such as a gummatous meningitis would have presented; the papillitis was in the left eye only; the frontal branch of the ophthalmic division of the fifth was involved early in the case, while the nasal branch remained free for some months; it was presumably involved for the first time at about the date that the anæsthesia and infiltration of the cornea were recognised. The ophthalmic division of the fifth in the posterior part of the lateral wall of the cavernous sinus is a single trunk.

There were no signs of a cavernous thrombosis. The third nerve may have been involved as a whole or after its division into superior and inferior branches; the diplopia long preceded the ptosis, but the fourth and sixth nerves being also paralysed when the patient came under observation no trustworthy inference can be drawn from this fact. If the proptosis was more than a total ophthalmoplegia could explain, an apical periostitis could account for it.

## Case 17.

### *Paralysis of Left Sympathetic Nerve from Pressure of a Goître.*

A. B., female, aged 42. I was asked to see this patient to advise as to glasses for near work, in June, 1896, when she was an in-patient of St. Thomas's Hospital on account of a goître. The goître was becoming reduced in size under medical treatment and no operation had been performed—the enlargement was of a parenchymatous nature and non-pulsating; the left lobe of the gland was much bigger than the right, and was displacing the trachea to the right side of the neck. She informed me that the neck-band of her dress was three and a half inches less at Easter than it had been in the previous January. She had lived in Oxfordshire, London and Bournemouth.

I found the refraction to be R. V. $\frac{6}{6}$ h.m. 0·5 D.
L. V. $\frac{6}{6}$ h.m. 1·0 D.

Chooses R. + 1·5 DS. and L. + 2·0 DS. for near work; gets 1 J., and uses these binocularly for reading.

I observed on the left side slight ptosis and narrowing of the palpebral fissure, and the upper lid was not raised so efficiently as its fellow when the eyes were directed

upwards. No retraction of the globe on the left side was appreciable to inspection. The right pupil measured $4\frac{1}{2}$ mm.; the left 3 mm.; on each side the pupil acted normally with convergence and with direct and indirect stimulus of light. By the use of cocaine drops to both eyes equally, the inequality of pupils was rendered much more conspicuous; the left pupil did not respond at all to the drops and still measured 3 mm. in diameter, while the right had enlarged to 7 mm.; the lids on the right side also became considerably retracted after the use of the cocaine, while no such effect was produced on the left side, so that the difference between the width of the two palpebral fissures was increased.

There was some congestion of the palpebral conjunctiva of the left eye and a little excess of mucus in the left conjunctival sac compared with the right, and the patient was aware that the left lids "gummed" during sleep, but not those of the right eye. She perspired on the right side of the head and face, but not on the left side, and this was obvious on the day in June that I saw her. She was aware of no alteration in her voice. I could make certain of no inequality in volume in the two temporal pulses.

I regret to say I have no note of an ophthalmoscopic examination; I feel sure such was made, and had anything noteworthy been observed I should have recorded it.

## Case 18.

*Paresis of Right Sympathetic Nerve; following Re-vaccination in a Patient with Tuberculous Family History; Rami Communicantes from the Cord presumably affected.*

A. C., female, aged 33, cook, seen privately on October 24, 1901. The patient was re-vaccinated by an experienced practitioner on October 1, 1901; the local

reaction was a comparatively mild one, and no fever that was recognised supervened.

On October 12, 1901, she had pain in the mid-line of the back and located it over the spinal column about the lower dorsal region ; it was accompanied by severe abdominal pain that resulted in retching and vomiting ; was so acute it doubled her up and prevented sleep, and after lasting three or four days left the abdominal wall tender. Two days after the onset of the abdominal pain an aching pain developed at the back of the neck ; she indicated it to me over the spine of the last cervical vertebra ; it did not seem to be more acute on one side than on the other ; the pain lasted nearly a week and then ceased ; when at its worst she could not move her head, and it became aggravated at night ; on October 24, there remained only a sensation of stiffness at the base of the cervical column.

Her father died of consumption and her sister was an in-patient of Brompton Hospital for her lungs when 16 years of age. There was no family history of rheumatism or gout, but about a year previously the patient had had some swelling and pain in the region of the left elbow joint.

Coinciding with the attack of pain at the root of the neck drooping of the right upper eyelid was observed, and in connection with this she was sent to me. I found the right upper lid distinctly drooped ; but could appreciate no elevation of the fellow lower lid ; the movements of both eyes were normal. There was no proptosis or recession of eyeball, and no pain on making backward pressure on the right globe. The right pupil measured 3 mm. in diameter ; the left 4 mm. ; they acted well to light ; after one lamella of cocaine (gr. $\frac{1}{20}$th) had been used to each eye, without waiting for the full result the corresponding pupillary measurements were $3\frac{1}{2}$ mm. and $5\frac{1}{2}$ mm. respectively.

V. of R. $\frac{5}{24}$ $\bar{c}$ + 4·0 D. cyl.— = $\frac{5}{6}$ partly.

V. of L. $\frac{5}{6}$ partly ; Hy. estimated 4·0 D.

There was no evidence of unilateral sweating of head and face ; pilocarpine was not used and my examination was at the end of October. The patient was unaware of any one-sided dryness of mouth. I could detect no difference between the pulses on the two sides either in the radial or temporal arteries. There was no alteration of the percussion note below the clavicles ; no affection of voice ; no numbness, tingling or shooting pains in arms.

The knee-jerks were normal. The patient's complexion was of a rather lemon yellow tint.

I have no doubt the case was one of some affection of the spinal meninges ; first a focus appeared at the lower part of the dorsal region and gave rise to referred abdominal as well as to local pain ; two days later a second focus at the upper end of the dorsal region caused pain in this situation, and implicated the upper dorsal rami communicantes to the sympathetic chain of ganglia. One of my medical colleagues informed me that he had recently seen two cases of meningitis as sequelæ of vaccination ; at the time "A. C." came to me, owing to the prevalence of small-pox in London, vaccination was being largely resorted to. Had the symptoms in "A. C.'s" case remained permanent or proved chronically progressive I should have been inclined to look upon the trouble as being of a tuberculous nature, in view of her family history. Three weeks later, however, the patient saw me again ; the ptosis was not improved, but she was experiencing less pain at the root of the neck and none in the abdomen, and was obviously better in general condition. No time had as yet elapsed.

I saw A. C. again in September, 1902 ; she had continued under her doctor's observation until Christmas, 1901, and had at that date greatly improved. In

September, 1902, I found that the right pupil was just appreciably smaller than the left, and there was still a shade of ptosis of the right eyelid. Vision and refraction were unaltered and the fundi healthy. Her doctor thought the patellar jerk was more brisk in the left than in the right leg.

From the progress of the case I concluded that a tuberculous lesion might be excluded ; the history of onset and fairly rapid and complete recovery point, in my opinion, to the trouble being due to the vaccination, the toxæmia of which resulted in all probability in two limited inflammatory foci in the spinal meninges with implication of nerve roots.

### Case 19.

*Paresis of Extra-Ocular Muscle from Hæmorrhage into Muscle Sheath.*

A. W., female, aged 19, tailoress, saw me at the Royal London Ophthalmic Hospital on January 11, 1902. She stated that the sight of either eye was clear when used alone, but that with both eyes open simultaneously the vision was confused ; even with both eyes open if she turned them to the left she had discovered there was no dimness or confusion ; but this at once resulted if the eyes were turned to the right side, so that she blamed the right eye. In this respect she was accurate ; I found that abduction of the right eye could not be quite completely performed ; the candle test was employed and her answers confirmed the suspicion that the right external rectus was acting imperfectly. I learnt that a fortnight earlier the patient had had a bilious attack ; she was not subject to such disorders ; she experienced frontal headache which was not unilateral and which lasted four days ; during the first two days of the illness she vomited repeatedly, and

it was during this illness that the confused vision developed. There was no history of any sub-conjunctival ecchymosis and no trace of any such extravasation at the time I saw her. I diagnosed the case as one of hæmorrhage into muscle sheath, gave a favourable prognosis and prescribed no medicinal treatment.

Eleven days later the patient returned; there was no longer any dimness of vision or diplopia, and the patient was carrying her head straight instead of rotated to the right, which was its posture on the occasion of her first visit.

### Case 20.

### *Paresis of Extra-Ocular Muscle from Hæmorrhage into Muscle Sheath.*

Miss R., aged 68, but looks younger, consulted me privately on August 29, 1901; two months before she had seen an ophthalmic surgeon, a colleague of mine, because she had been experiencing double vision when the eyes were elevated; my colleague had gone very carefully into the case and come to the conclusion that the diplopia was due to paresis of the left superior rectus muscle; no other muscle was involved and he concluded that the defect was caused by hæmorrhage into the muscle sheath, and was not a nerve affection. At his suggestion the urine had been examined and found normal. The patient came to me because the right eye had been bloodshot for one week; she had had slight redness of an eye on one occasion some years before; she said her eye was not now painful. I found the appearance was due to a large extravasation of blood beneath the ocular conjunctiva; there was no history of epistaxis, or œdema of ankles. This spontaneous ecchymosis was corroborative evidence of the accuracy of the diagnosis of the diplopia made two

months previously by my colleague; at the time she consulted me the diplopia had quite disappeared.

## Case 21.

### *Diffuse Cellulitis of Orbit Secondary to Empyema of an Ethmoidal Air-Cell.*

The following article by the author is reprinted from vol. xxvi. of the "*St. Thomas's Hospital Reports*":—

Cases of orbital cellulitis set up by empyema of one of the ethmoidal air-cells appear to be so rare as to make it desirable that one recently under my care should be recorded. Orbital cellulitis itself is fortunately not a very common occurrence; in one year at the Royal London Ophthalmic Hospital, Moorfields, out of 12,692 patients seen, Spencer Watson found only four who attended on account of this disease, and was at very considerable trouble to find reports of thirty cases in the whole of the literature bearing on the subject. This investigation he conducted for an article in the *Medical Mirror* many years ago. None of these thirty cases of cellulitis of orbit were attributed to disease of the ethmoidal air sinuses, and it is interesting to note that at this time a considerable number were due to infection from pyæmia, originated in several instances by suppurating scalp wounds, or to facial erysipelas. These conditions are no doubt less often met with as causes of orbital cellulitis at the present day.

George W. Caldwell, in the *Medical Record* for April, 1893, p. 425, says, "Numerous cases are recorded of orbital periostitis and cellulitis from extension or infection from purulent ethmoiditis." This general statement I must say I have been unable to confirm. I have carefully examined the *Royal London Ophthalmic Hospital Reports*, the *Transactions of the Ophthalmological Society*, and the *Archives of Ophthalmology*, and I have failed

to find any case in which it has been proved that a cellulitis of orbit has been set up by pus formation in an ethmoidal air-cell. Eales, in the *Birmingham Medical Review*, vol. xvi., records several cases of acute cellulitis of orbit, in some of which such a cause seems likely, though he himself does not suggest it, and it was not proved either during life at the operation or in any fatal case at the autopsy. In the Moorfields Hospital *Reports*, vol. xii., p. 281, Treacher Collins reports a case of suppuration in the orbit which proved fatal by cerebral complications; at the *post-mortem* examination pus was found in both the frontal and ethmoidal air sinuses, but the cause of the cellulitis is attributed by him to acute periostitis of the roof of the orbit, the infection having been probably through a carious tooth; an area of necrosed bare bone in the orbital roof was found *post mortem*.

Knapp, in the *Archives of Otology*, vol. xxii., p. 313, has an interesting article bearing on disease of the air-cells connected with the nose, and shows how they may become distended with serous fluid, with mucoid fluid, or with pus. He quotes in all seven cases. The first is one in which the ethmoidal cells became distended with serous fluid and caused proptosis and displacement of the eye; in the second a similar displacement was due to a mucocele of the ethmoidal cells; each of these was successfully treated by evacuating the contents through the orbit, and in the third case the fluid tapped by the same route was pus. The fourth and fifth cases were examples of combined distension of ethmoidal and sphenoidal air sinuses, the fluid contained being purulent, and being reached as before along the inner wall of the orbit; in the fourth case a fistulous track remained when the patient was seen three years later, and in the fifth a similar condition existed when seen four months after

operation. The sixth case of Knapp's was similar to three recorded by Holmes in the *Archives of Ophthalmology*, vol. xxv., p. 460, viz., empyema of-the sphenoidal air-cell only. The seventh was one in which pus was found *post mortem* in all the air sinuses in connection with the nose ; the fatal result was due to purulent meningitis of both base and convexity of the forepart of the brain ; the communication had occurred through the cribriform plate and the orbital roof. This was the only case of the seven in which the patient had the general acute symptoms which we associate with orbital cellulitis ; and even in this case, on which Knapp operated, he describes his operation as incising the skin near the inner canthus, enlarging the incision, laying bare the tumour which was causing the displacement of the globe, cutting into its wall, and evacuating pus. From this description it seems certain the pus was quite surrounded by a wall, and that this case was not one of diffuse orbital cellulitis ; in the other cases there were no acute symptoms at all, and in each the operation consisted in dissecting along the inner wall of the orbit till the bulging outer wall of the ethmoidal cells was reached, and then opening the swelling. They are not in any sense cases of cellulitis of the retro-ocular tissue, and are recorded in the *Archives of Otology ;* the only interest to the ophthalmic surgeon was the operative procedure adopted, and the displacement of the eye to which, in each instance, the diseased air-cell gave rise. In the light of my own case, however, I suppose any one of them, if the outer limiting wall of the swelling had given way, would have rapidly been complicated with acute cellulitis of orbit.

A case of orbital cellulitis which probably was due to empyema of an ethmoidal air-cell is that of Schäffer, *Prag. med. Wochenschrift*, 1883, No. 20 ; here pus was evacuated by incision through the lid, and in syringing

it was found that the fluid passed into the nose; the patient died of meningitis. The primary cause of obstruction to the outlet of the ethmoidal cells involved appears to have been nothing more than an acute nasal catarrh.

Hartmann has recorded a case in which, after exophthalmos, a discharge of pus occurred from the nose; this flow of pus could be rendered more abundant by pressure on the eyeball; the globe receded, and recovery took place; no operation was necessary. It seems to me this must have been a case comparable to the third of Knapp's series; there was no infection of the retro-ocular tissue. Hartmann found the cause of the ethmoidal empyema was chronic hypertrophic rhinitis; the case is quoted by Berger and Tyrman, *Die Krankheiten der Keilbein-Höhle und des Siebbein Labyrinthes*, Wiesbaden, 1886, p. 14.

Bosworth, in his "Diseases of the Nose and Throat," gives the following as causes of occlusion of the ostium ethmoidale in addition to those incidentally referred to above: syphilis and tubercle, affecting presumably either bone or mucous membrane; polypi, simple or malignant; very rarely traumatism; and as a possibility he mentions phosphorus necrosis among those employed in match factories.

The diagnosis of distension of the sinuses in connection with the nose hardly comes within the scope of this article; from the point of view of the ophthalmic surgeon it may be well, however, to recollect the chief causes of conditions which may be responsible for the symptoms of a small proportion of those who complain of aching pain at the back of the eyes, and which in exceptional cases may give rise to displacement of the globe, and still more rarely to diffuse orbital cellulitis. An examination of the nose might occasionally enable a more accurate diagnosis than asthenopia to be made,

explain a proptosis, or reveal the origin of an acute suppuration of the orbit.

It has been suggested that in some at least of the cases recorded of optic papillitis associated with the dropping of clear fluid from the nose, the source of such fluid is a dilated air-cell. I would point out, however, that the absence of nasal discharge does not exclude disease of the air-cells, obstruction to their communication with the nose in some form or other being the condition necessary for their distension with fluid, whether serous, mucoid, or purulent. As examples of ethmoidal distension when no nasal discharge existed we have one case recorded by Vermyne in the *American Journal of Ophthalmology*, 1884, vol. i., No. 5, p. 129; another by Knapp at the Fifth Ophthalmological Congress, New York, 1876, p. 55; and one by Sonnenberg, *Deutsche Zeitschrift für Chirurgie*, 1877, vol. vii., p. 500. When nasal discharge is present the next step towards an accurate diagnosis will be to determine from what air-cell it is coming. With fair accuracy the presence of turbid fluid in the maxillary antrum or frontal sinus can be recognised by the method of transillumination. If a posterior ethmoidal air-cell be the source of the fluid the discharge will be flowing over the convex side of the middle turbinate bone; in this case it will be likely to pass backwards through the posterior nares and be missed altogether. From the maxillary antrum, the frontal sinus, or a cell of the anterior ethmoidal group the secretion is discharged into the middle meatus of the nose, and escapes at the anterior nares; it is suggested that its flow will be more abundant when the head of the patient is lowered, or in the case of the antrum of Highmore laterally inclined. Discharge from a posterior ethmoidal cell is said to be most free when the head is held erect. Such observations concerning the influence of position on the amount of discharge must be difficult to make, and at all

times somewhat uncertain. I have at the time of writing under my care a case of frontal empyema of the left side in which nasal discharge had previously come abundantly through the right nostril ; presumably the left infundibular cells being occluded, a mucocele formed, and the septum between the two frontal sinuses being, as it often is, incomplete, the collection discharged into the nose by the only available route, viz., the right infundibular passage. When operating at another time on a case of frontal empyema, in endeavouring to pass a probe from the diseased sinus by which to draw a drainage tube into the nose, I was, for a moment, somewhat surprised to see the probe appear at the opposite nostril.

Knapp was able to operate on six cases of ethmoidal cell distension through the orbit, and in no case did emphysema result ; and in the case I am about to relate of orbital cellulitis no emphysema existed, although this is almost an invariable result of fracture of the bony wall of any of the air sinuses surrounding the orbit. This seems to show that no patent communication with the nose exists in cases of ethmoidal cells distended sufficiently to give rise to displacement of the eyeball or to rupture so as to cause diffuse cellulitis of the orbit.

That more cases of orbital cellulitis, traceable to ethmoidal empyema, are not on record is the more remarkable when we recollect that the mucous lining of these cells in its deeper layers performs in addition the duties of a periosteum, and that its acute inflammation is consequently very prone to result in necrosis. Curiously, Vossius in v. Graefe's *Archives*, vol. xxx., narrates a case where a retro-ocular abscess perforated into the ethmoidal cells and nose by necrosis of the os planum ; it seems possible that this may really be a case analogous to my own.

Anatomical points, not yet incidentally alluded to, it may be well to recall. The frontal sinus and anterior

ethmoidal cells are in direct communication, and the infundibulum opens into the middle meatus of the nose very close to the communication of the maxillary antrum with the same meatus. There is no communication between the larger group of anterior ethmoidal cells and the smaller group of posterior ethmoidal cells, but the latter set is often in direct continuity with the sphenoidal air sinus. The lateral mass of the ethmoid bone does not begin to be excavated by cells till the fifth year after birth, and enlargement goes on for a considerable period after this date. The majority of Knapp's cases quoted above occurred at about the time of puberty or soon after, but some in middle life ; there is of course no distal limit of age at which the air sinuses may give rise to trouble.

Thomas C—, labourer, aged 17, came to the Out-patient Department on August 9, 1897. There was much brawny hard swelling and dusky red discoloration of the upper lid of the left eye ; there was very great proptosis, the displacement of the globe being in a direction forwards, downwards and slightly outwards ; a small scar was observed at the inner end of the upper lid on the diseased side, where an abscess was said to have discharged on more than one occasion previously. The cornea was left partly unprotected by the upper lid, and over this exposed portion its epithelium was slightly pitted and irregular. There was great œdema of the ocular conjunctiva as far as this membrane could be inspected. The pupil reacted to light. The pre-auricular lymphatic gland was enlarged and tender. The patient presented all the appearances of being acutely ill, and the pain was very severe ; the temperature was raised to 100° F.

The history was extremely difficult to obtain ; the boy's father, who came with him, though very willing to accept advice and give me a free hand for treatment,

was absolutely incapable of giving me any account of the condition or of answering questions. The patient was very deaf indeed, and had had discharge from both ears on and off for five years, for which he had been treated in the Ear Department of the Hospital; the deafness had progressed till it was very difficult to make him hear at all; he had also been subject all his life to epileptic fits.

The cause of his mother's death was unknown; his father enjoyed good health. The patient was the fourth child of five living; three born since the patient had died in early life—one of bronchitis, one who was born prematurely at the seventh month, and one died when six months old, the cause being unknown.

About three years ago the patient was said to have had a small discharging abscess in the left upper lid, which came and went several times without causing much inconvenience; it was unfortunately quite impossible to get further particulars of this trouble.

The boy had been in quite good health until his present illness commenced on August 6, three days before I saw him; he had received no injury to the eye or lids, but was struck lightly on the cheek with a piece of firewood earlier in the day on which the swelling began; this blow had left no mark, and seemed to have been altogether trivial.

The bridge of the nose was much depressed, the forehead square with prominent frontal bosses. The teeth, however, were not characteristic of inherited syphilis, though I suspected him to be the subject of this taint, and for the greater part of his stay in the ophthalmic ward he was taking antesyphilitic remedies. The urine was normal.

He was at once admitted on August 9, and the same afternoon ether was administered, and I incised deeply

along the roof of the orbit through the upper lid; a large quantity of pus of rather an oily nature at once escaped; I opened up the collection more freely by expanding in it the blades of an artery forceps introduced closed along my incision; the cavity was explored with finger and probe; bone was felt, but not denuded or carious. A drainage-tube was left in, and cyanide dressing employed. The next day I had expected to find considerable change for the better both in the local and general condition, but was disappointed; though pus was coming freely through the drainage-tube there was no improvement. A purgative had acted well. I changed the dressing to one of hot boracic lotion every four hours.

On August 11 the discharge was noticed to be offensive; the eye was as much proptosed as ever, and its condition more serious in that the cornea, where unprotected, was now definitely ulcerated.

12th.—The lid looked likely to slough; there was no diminution in proptosis; offensive discharge was coming freely away from the tube; the ulcer of cornea was more extensive and yellow. The pulse was slow; the patient complained of severe pain in the head, though lying generally in a drowsy, lethargic state; the temperature had not fallen, but remained at about 100° F. I had ether again given, enlarged my incision, and scraped out some sloughing tissue; I slit vertically the upper lid in its whole thickness to relieve tension, a proceeding warmly advocated by Tweedy in such cases. I made incisions into the chemosed conjunctiva around the cornea, and a second opening into the orbit through the lower lid; this incision, however, did not reach pus, and none came through the tube which I inserted. I cleaned and replaced the original drainage-tube, which acted well.

Fuchs draws attention to the presence of symptoms usually regarded as cerebral in uncomplicated cases of cellulitis of orbit; when the cranial cavity and its contents are in no way involved these cases often show such symptoms as headache, vomiting, mental hebetude, and retardation of pulse.

The day following my second operation the temperature was 98·6° F., pulse 54; the eye slightly less prominent, and the swollen lids softer and pitting more easily on pressure. I examined the right optic disc, and was glad to find it quite healthy; it was not possible to get any view of the condition of the fundus of the left eye.

On August 14 a sinus had formed spontaneously from the depth of the orbit, with an orifice in the skin of the left upper lid near the internal canthus. This sinus continued to discharge abundantly; the proptosis gradually diminished; the purulent ulcer of cornea very slowly healed; the temperature remained normal, and the general condition improved until this boy became the most troublesome and unmanageable in the ward.

On August 17 I probed the spontaneously formed sinus; my note is—"A probe from the recently self-formed opening can be passed backwards for about one and a quarter inches, and then appears to pass through a hole in the os planum of the ethmoid, which plate of bone feels as if it may be bulged towards the orbit; the probe is in contact with some bare grating bone on its outer side when passed through the supposed aperture, and one piece of this bone feels as if it were slightly moveable. A tube was introduced to-day to the bottom of the newly-formed sinus."

The sinus gradually contracted, but on August 27, as it gave no signs of completely healing, Mr. Lawford in my absence enlarged and explored it under an anæsthetic;

he found it passed down to a surface of bare bone perforated by two or more holes into the ethmoidal cells; through one of these apertures a bent probe was passed into the nose, and brought out at the left nostril; by its means a rubber drainage-tube was drawn along the same route, and, with lateral openings in it, its ends were left projecting at the nostril and the orifice of the sinus respectively.

From this time a considerable quantity of offensive pus passed by the tube and was discharged by the nostril, and so continued until the night of September 6, the tube being kept clean and clear by syringing through it at each dressing.

On the morning of September 7 the tube was found to be out, and had probably been withdrawn by the patient who was constantly interfering with his dressings. From this date syringing was performed directly into the sinus in the upper lid. On one occasion this gave rise to slight bleeding from the left nostril, showing that a patent communication with the nose still existed; epistaxis also occurred slightly on two or three other occasions spontaneously from the same nostril during the week following the removal of the tube.

On October 4 the sinus went back as far as ever, and the probe still encountered bare bone at the end of it, and on October 7 all the fluid syringed into the orbital sinus came out through the mouth or left nostril.

On October 1 Mr. E. C. Stabb was kind enough to examine the nose for me in the Throat Department, and reported—"Both nostrils are blocked by hypertrophy of inferior and middle turbinate bones. No adenoids. Both antra free (by transillumination). Both frontal sinuses free also. Dead bone (extensive), inner wall of orbit."

After this report I again examined the right eye carefully for any further indication there of congenital syphilis,

but could find none. Shortly after the patient was transferred to Clayton Ward, my idea being that it would be necessary to clear the nose before the orbital sinus would heal. Mr. Pitts, however, did not think this necessary, and his view was confirmed by the sinus closing soon after the patient left Clayton Ward. Mr. Pitts regarded the patient as having inherited syphilis, and he continued the course of iodide of potassium.

A good deal of deformity of lid resulted from the vertical division of it which I made at my second operation ; the mucous membrane of the outer part everted and the lashes were displaced. This disfigurement I have since remedied by again dividing the lid and suturing it ; probably this deformity would have been less marked and less troublesome to deal with if I had slit the lid as close as possible to the outer canthus.

I have very few remarks to add to those which I have already incidentally made in the early part of this paper in alluding to the various cases I have been able to find with some bearing on my own. Thomas C. was throughout a case of great interest to me ; and as I have not found another reported which seems quite analogous, I have thought it desirable to record it somewhat fully.

From the depth at which the communication between the orbital and nasal cavities was found, $1\frac{1}{4}$ inches from the orbital rim, I have no doubt this was a case in which the posterior ethmoidal group of cells was the seat of disease ; that it was not one of the anterior ethmoidal set is confirmed, I think, by the fact that the frontal air sinus was healthy. The cause of blocking of the ostium ethmoidale was no doubt the chronic hypertrophic rhinitis, which in turn was probably a manifestation of hereditary syphilis. I regret that the nebulous condition of the left cornea, which in its lower half is very slightly staphylomatous, prevents me from ascertaining what changes, if

any, have taken place in the fundus of the eye on the affected side.

## Case 22.

*Encysted Mucocele of Orbit; Spontaneous Cure.*

C. D. L., male, aged 64, consulted me privately in December, 1898. His previous and family history had no bearing on the case and did not suggest any acquired or inherited constitutional disease. Six days before I saw him the left eye became watery and weeping; he attributed it to exposure to a draught from a railway carriage window; this condition continued for four days and was not benefited either by the hot or cold applications which he made to the eye. The watering of the eye became more troublesome; circum-orbital pain developed and was sufficiently severe to keep him awake during the night preceding his visit to me. When I saw him he complained of feeling weak and faint, experienced sensations of nausea, but had not vomited.

I found his left eye slightly proptosed; the upper lid was a little puffy and drooped over the eyeball; he had power to elevate it but not very completely; there was a little excess of secretion from the conjunctiva and the ocular portion of the membrane was œdematous. The movements of the eyeball were greatly limited; in the directions of elevation, depression and adduction movement was almost but not quite in abeyance; abduction was better performed but was by no means complete. On elevating the upper lid diplopia was at once apparent to the patient. There was a distinct resistance to backward pressure made upon the eyeball through the closed lids; such pressure was not painful. There were no enlarged lymphatic glands. Sensation over the fifth nerve area was not affected.

The cornea, pupil, iris and tension of the eye were all normal. The patient was hypermetropic and with correction the vision of the affected eye was as good as that of its fellow. Ophthalmoscopic examination was made after dilating the pupil ; there was no fundus disease ; no change in the optic disc or its vessels.

I saw Mr. L. again four days later. The proptosis had not increased but the displacement of the eyeball was now in a direction more outwards than when I saw him first ; and the power of voluntary adduction had become still more reduced. The other movements and signs were unaltered, but his pain was much relieved and his general condition in consequence brighter. I ascertained that he had been in India ; the possibility or orbital hydatid cyst occurred to me. There was no history or objective evidence pointing to air sinus trouble, but the nasal septum was displaced to the left. The patient was taking iodide of potassium and tolerated it well, though the first few doses set up some coryza.

On December 23 I saw him again. On the night of December 21 he awoke, and found an abundant discharge taking place from his left nostril ; he thought at first his nose must be bleeding, but found the fluid which was coming away was like white of egg and somewhat offensive in odour ; there was still more of the same discharge on waking in the morning. When I saw him the left eye was still just appreciably more prominent than the right, but had greatly receded ; the movements of elevation, depression and abduction were almost fully restored ; adduction could be performed till the eye was brought just internal to the primary position. Œdema of the conjunctiva had subsided ; a sense of increased resistance to backward pressure could still be appreciated.

A week later he said he was very well. He continued

to have a little excessive discharge from the left nostril from time to time ; when a flow occurred it gave relief to slight pain which he occasionally felt ; he also experienced at intervals in the left side of his nose a tingling sensation, which sometimes induced sneezing. All displacement of the eyeball had disappeared. The only defect in movement was a slight incompleteness of adduction.

I warned him that there was a possibility of recurrence of trouble in which case he was to see me again ; I left him in charge of the medical practitioner who brought him for my advice ; as I have not seen him since he has probably remained well. There was never anything to be felt in the orbit by palpation.

The displacements of the nasal septum to the left, and of the eyeball outwards as well as forwards are suggestive ; adduction was the last movement to be recovered. An empyema in the lateral mass of the ethmoid, bulging towards the orbit seems the reasonable diagnosis. Whether the iodide contributed to his cure by its effect on the nasal mucous membrane, helping to clear the ostium of the air-cell involved, can hardly be determined.

## Case 23.

### *Septic Thrombosis of the Cavernous Sinus.*

The following article by the author is reprinted from vol. xxviii., of the *St. Thomas's Hospital Reports.*

Cases of septic thrombosis of the intra-cranial venous sinuses are always of interest, and records of cases are rare in which the disease primarily affects the cavernous sinus.

With the train of pyæmic symptoms which follow the extension to the lateral sinus of suppurative inflammation starting in the middle ear, we are now well familiar. It is, of course, a natural inference, that similar general results will follow septic thrombosis of a cavernous sinus; the difficulties of diagnosis, however, are at first sight greater in the latter class of case, mainly, no doubt, because examples of this class are much more rarely met with, while the difficulties of treatment are so insuperably greater, that at present it seems hardly possible to bring such a case to a successful termination.

Setting aside cases of non-infective thrombosis secondary to fracture of skull, we have two main causes of formation of clot in the intra-cranial sinuses, viz., marasmus and sepsis.

The marasmic cases are rare, and are met with most often in patients at the two extremes of life, usually as the result of prolonged exhausting diseases. The clot forms as a rule in the superior longitudinal sinus, more rarely in the lateral sinuses, and still more rarely in the cavernous sinuses. When examined *post mortem* the clot is dense, resistant, stratified, and non-adherent to the walls of the vein; the brain area affected is likely to be œdematous, the vessels congested, and innumerable minute hæmorrhages are generally found in the gray cortex; the ventricles may be distended with fluid, and exceptionally sero-sanguineous fluid draining into the orbit has caused some exophthalmos during life.

Infective thrombosis, in contrast, most often occurs in adults, rarely in old people, and only exceptionally in children. It usually affects one of the dual sinuses and not the single median or azygos sinuses. It is local in origin, secondary to some septic inflammatory lesion, and usually involves the sinus in the most anatomical proximity to the primary disease. Compound fractures of skull, or even

septic scalp wounds without fracture may give rise to it, while otitis media suppurativa is the most frequent cause ; empyema of the sphenoidal air-cell at once suggests itself as a cause. Simpler lesions, such as ulceration of the mucous membrane of the nose, periostitis of maxillæ from carious teeth, tonsillar and retro-pharyngeal abscesses, have been responsible ; while specific inflammations such as erysipelas of face, carbuncles, and anthrax pustules, cellulitis and acute infective periostitis of orbit, have accounted for recorded cases. *Post mortem*, the clot which has formed on the inflamed walls of the sinus implicated is usually found disintegrated into pus ; there is no tendency to brain softening, while hæmorrhages in the cortex are only rarely met with. If the patient has survived sufficiently long, purulent meningitis is almost sure to have developed, while pyæmic infarcts may have given rise to cerebral or cerebellar abscess, or purulent deposits in more remote parts of the body. On the signs which such secondary foci will show during life I do not propose to enter ; the reader can well recall them for himself, and can also, to complete the picture of the disease, fill in the general symptoms of pyæmia, many of which the case I record below exemplifies.

Mr. Kilvert, to whom I am much indebted, has kindly searched in the hospital records for cases of septic phlebitis of the cavernous sinus for the past twenty years. It is probable that not all the cases have been unearthed ; the different classifications of successive registrars, and the various diagnoses under which such cases may have been entered, rendered the search a particularly difficult one. Mr. Kilvert has only succeeded in discovering notes of three such cases, and of these two were in children, so that it is obvious we should not lay too much stress on the question of age. In all three cases the primary disease was a suppurative otitis media ; there was evidence *post mortem* of extension by continuity of the phlebitis from the lateral

sinus primarily involved in the two cases where full notes were available, and in each of them the usual operation in the mastoid region with ligature of the internal jugular vein in the neck had been performed. Each, during life, had the local signs indicative of the cavernous sinus being involved; these signs are for the most part readily understood, when we recollect that the veins of the orbit drain into the cavernous sinus, and that the motor nerves of the eyeball, and the first division of the fifth nerve are in intimate relation to its walls. The local symptoms may be briefly summed up by saying that on the affected side, we get a rapid development of all the appearances suggestive of cellulitis of the orbit: intense brawny inflammatory œdema and swelling of lids, very considerable proptosis of eyeball, chemosis of ocular conjunctiva, fixation of globe, pupil often dilated and moving imperfectly, tenderness on palpation, and an elastic feel very suggestive of fluctuation; a certain amount of muco-purulent discharge from the conjunctiva is often present. The pain is severe, but the patient, in a drowsy condition, often complains but little of it; supra-orbital neuralgia has been intense in some cases. My own patient developed a symptom which is to be observed in a large proportion of these cases, and one which makes the diagnosis from cellulitis of orbit certain, *i.e.*, the local signs become bilateral; the eyeball and orbit of the opposite side begin to show changes similar to those on the side first involved; in some cases a slight abatement of signs on the original side accompanies this extension. Whether this be so or not, this extension of symptoms is quite diagnostic from orbital cellulitis, and indicates, of course, a spread of phlebitis by means of the circular sinus to the cavernous sinus of the opposite side. One other point on which some stress is laid in the diagnosis from cellulitis of orbit is the presence of œdema over the mastoid region, which is said to be likely to be present in the

thrombotic cases only ; in cases originating in middle-ear disease this sign could hardly be relied on. I regret to say I omitted to make this observation on my own patient, though I had it in my mind to do so. I am not, however, inclined to attribute great value to this point. In thrombosis of the cavernous sinus, I should consider œdema of the retina with distended veins as more likely to be of use ; still this condition of retina is not necessarily present, even with a completely blocked cavernous sinus if the ophthalmic veins remain patent ; the alternative channels of venous return are sufficiently free to prevent its development.

The anatomical venous connections of the cavernous sinus I take to play a very prominent part in the development and course of the disease, whose main pathological features are found in its phlebitis. By these connections we are able to explain the many diverse situations of the primary septic disease from which the cavernous sinus may become involved ; the same free communications afford so many alternative routes by which the blood may leave the cavernous sinus, that it seems vain to hope we shall be able, by ligature of the internal jugular vein, to prevent general pyæmia in these cases, as is now frequently successfully done when a case of septic thrombosis of the lateral sinus has to be treated. This ligature was applied, but without success, in two of the three cases we have discovered in the hospital notes, as each was a case primarily of infection of the lateral sinus from otitis media. Anteriorly the cavernous sinus receives the ophthalmic veins, the free communication of whose radicles with the angular vein is well known ; posteriorly it is drained by the superior and inferior petrosal sinuses ; internally it is put into free communication with its fellow of the opposite side by the anterior and posterior inter-cavernous sinuses ; externally it receives the so-called spheno-parietal sinus by which connection with the middle meningeal vein is established ;

while inferiorly through the foramen ovale, the foramen lacerum medium, and that of Vesalius, emissary veins drain the sinus into the pterygoid and pharyngeal venous plexuses. These two plexuses communicate together, and each drains into the internal jugular vein; while the pterygoid plexus by the anterior internal maxillary vein has a free flow into the facial vein, and will communicate through the inner wall of the spheno-maxillary fossa with the veins of the nasal mucous membrane. At first this network of alternative venous channels sounds very appalling; still, when the ultimate destination of all these veins is considered, it does seem likely that a ligature on the internal jugular vein low down in the neck ought to be tried. The most formidable feature of all is still the circular sinus joining the diseased sinus to its fellow; spread in this direction almost always takes place, and it would be a bold step to tie the opposite internal jugular vein immediately on the symptoms pointing to this extension of the phlebitis, or even before, in either case a very short interval after the first internal jugular vein had been occluded by ligature. In my own case injections of anti-streptococcus serum were employed. I cannot record any appreciable benefit from this measure, and am not aware that it has previously been tried in a case of septic phlebitis of the cavernous sinus; possibly with the internal jugular vein tied a better effect might have been produced, and if I had another such case under care, I should be inclined to try this combined treatment.

E. M—, aged 22, female, domestic servant, was admitted to the hospital on September 22, 1900. Three days before she noticed slight pain at the inner side of the left eye, "she thought a stye was coming." On September 21, on account of great pain and commencing swelling and redness of lids, the doctor was called in.

Towards evening she became worse, vomited, and her temperature was found to be 104° F.

On admission she said the pain had been so severe she had not slept for two nights; it was now all over the head, but was especially complained of at the back of the neck. She had had repeated vomiting. The temperature on admission was 101·6° F.; the tongue and mouth were coated with dirty white *débris;* the bowels acted after an enema administered on the morning of the 22nd, but had been confined for two days. The throat appeared healthy. Her diet had consisted of milk only.

On the left side there was much redness and firm œdematous swelling of both eyelids. Very considerable proptosis of eyeball—the globe appeared quite fixed; there was chemosis of ocular conjunctiva and slight muco-purulent discharge—the cornea was bright; the pupil was larger than that of the right eye, but not fully dilated; its action is not recorded. Through the brawny upper lid an elastic sensation could be felt; there was much tenderness on palpation. The right eye and orbit were perfectly normal.

There was no discharge from the ears, and the patient had been in every respect perfectly well up to the time of the present attack.

Regarding the case as probably one of cellulitis of orbit, at 4 p.m. on September 22, I had anæsthetic administered and incised deeply into the orbit through the upper lid. No pus was evacuated. I thought I felt some rough bone with a probe near the junction of the upper and inner walls of the orbit. A drainage-tube was inserted and cyanide dressing applied. I took the opportunity of examining the right fundus with the ophthalmoscope and found it in all respects normal. The condition of the lids prevented examination of the left fundus.

At 8 p.m. the same evening her temperature was 105° F. I ordered the dressing to be changed to one of hot boracic lotion every three hours; ordered her brandy and five grains of calomel.

At midnight the temperature remained the same. Pulse was 120, and it was noted that the right eyelids were becoming œdematous.

Next morning, September 23, the right lids were more swollen; there was some œdema of ocular conjunctiva on this side, and no power of elevating this eye, all the other movements remaining intact. The condition on the left side had not altered; no pus had come through the tube; there appeared to be a spot of most acute tenderness near the inner canthus.

The calomel had acted well. There was no improvement in the general condition. The development of symptoms on the right side made it clear that there was thrombosis of the cavernous sinus. Considering it possible that bone disease of the left orbit was the primary mischief, I had anæsthetic again given, and thoroughly explored the orbit, splitting the upper lid vertically, and incising also through the lower lid. The bare bone I thought I could still detect with the probe in the upper inner part of orbit. No pus was evacuated.

At 1.30 p.m. 10 cc. of anti-streptococcus serum were injected in the flank, and this dose was repeated every four hours until 5.30 a.m. on September 24, stimulants being freely given.

At 5.30 p.m. on the 23rd the right lids were less œdematous, and there was some upward movement of the right eyeball, but it was very incomplete.

At 9.30 p.m. the œdema of right lids and conjunctiva had again much diminished; the eye was capable of movement in all directions; the pupil was active, and Mr. Kilvert noted "no papillitis."

The patient gradually sank and died on September 24 at 10 a.m.; the temperature rose to 107° F. just before death; there was no change in the appearances of the left eye.

A *post-mortem* examination was made by Dr. Colman on the afternoon of the 24th; he returned the case as one of septic thrombosis of cavernous sinuses, with local meningitis, but was not able to identify the source of infection. I can only suggest that it may have been an acute necrosis of left orbit, of which the small area of bone I felt at my operation was the evidence.

The body was well nourished; there was great proptosis of the left eyeball.

The skull-cap and dura mater were natural.

On removing the brain there was no excess of fluid at the base.

There was some matting in the inter-peduncular space, and some yellow thickening without definite pus formation over the left gyrus rectus and the right gyrus hippocampus, but no general meningitis.

No thickening along the optic nerves.

The cavernous sinus on each side contained puriform material, not specially offensive. The cerebral arteries showed some opacity, and one of the pontine arteries was distinctly thickened, suggesting syphilitic change. There was, however, no evidence of syphilis elsewhere, and there was a firm uninjured hymen.

The brain was otherwise natural.

The other sinuses, including the petrosal, were healthy.

Some hæmorrhage in the left orbital tissues from the operations, but no pus. The ears and sphenoidal air-cell were quite free from disease.

In the heart there was a considerable amount of atheroma at the commencement of the aorta, and one or two patches on the anterior cusp of the mitral valve.

The lungs were normal and showed no signs of tubercle.

The above is an almost full reproduction of Dr. Colman's *post-mortem* report.

The cardiac changes were rather unusual in one so young. Dr. Colman considered them typically atheromatous and in no way suggestive of ulcerative endocarditis.

A recent account of the diseases of the cerebral sinuses will be found in MacEwen's "Pyogenic Diseases of the Brain and Cord." In the *Transactions of the Ophthalmological Society*, vol. vii., will be found a paper by Dr. Sidney Coupland based on a case of thrombosis of the cavernous sinus: a table of a very considerable number of allied cases is appended, and illustrates well the various origins of this disease. Attached to Dr. Coupland's paper and table is an extended list of references that will be found of much assistance to any one interested in this subject.

# INDEX.

Afferent fibres of visual tracts, 8-9; course of, 13.
Air-cells, posterior ethmoidal, 87; anterior ethmoidal, 88, 99; antrum of Highmore, 97-98; frontal, 98; sphenoidal, 99.
Alexander's operation, 44.
Amnesia, visual, 18.
Anderson and Makins, 49, 50.
Aneurism, thoracic, paralysis of cervical sympathetic nerve caused by, 45.
Angular gyrus, function of, 10, 14; connection with visual sensory aphasia, 19; removal of (monkey), 22; position of, 50; cortex implicated in right-sided hemianopia, 144.
Angular process, internal, 88, 89, 100.
Angular vein, 89, 176.
Anophthalmic idiot, visual tract in brain of, 12.
Ansa Vieussenii, 44.
Anterior perforated spot, 5.
Aphasia, sensory, *see* Word-blindness *and* Word-deafness.
Argyll-Robertson pupil, 24, 110, 111; afferent fibres for, 129.
Arterial obstruction, homonymous hemianopia of central origin probably due to, 142-144.
Arterial spasm of retina, anatomical explanation, 42.
Arterio-venous aneurism of cavernous sinus and treatment of, 93, 94.
Association fibres, 8, 14, 15, 19, 29.
Auditory meatus, external, 50, 51, 135.
Auditory veins, 92.
Auricular nerve, great, origin, 48.
Auriculo-temporal nerve, cutaneous distribution, 48.

BASAL optic ganglion, 8.
Basilar artery, 21, 93.
Basilar sinus, 91, 92.
Basi-occipital bone, 91, 99.
Basi-sphenoid bone, 91.
Bechterew on the path of afferent impulses, 9.
Berger and Tyrman, 161.
Berry on congenital defects of lower lid, 104.
Blepharo-spasm, 82.
Bolton on the occipital centres for vision, 15-18.
Bone, defects of, in conjunction with dermoids, 106.
Bosworth on occlusion of the ostium ethmoidale, 161.
Bristowe, late Dr., case of pontine tumour, 25; *cited* on Lesion of corpora quadrigemina, 132.
Buccal cavity, 103.

CALCARINE artery, 21; obstruction of, causing homonymous hemianopia, 144.
Calcarine fissure, visual centre in, 10, 13-14; bifurcation of, 16; course of posterior end, 51; effect of lesion of, 134, 140.
Caldwell, George W., on orbital periostitis and cellulitis, 158.
Canaliculi, 83; congenital atresia of, 103.
Capsule, internal, course of visual fibres in, 10; blood supply of, 20.
Capsule of Tenon, 61, 62, 63.
Cardiac changes in case of septic thrombosis of cavernous sinus, 180, 181.
Carotid artery, common, ligature of, 93; internal, 5, 19, 86, 90, 93, 102.
Carotid plexus, origin and distribution of, 42.
Caruncle, 38, 80.
Cavernous plexus, origin and distribution of, 42-43.
Cavernous sinus, 5, 86, 90, 92, 99 113; septic phlebitis of, 174; septic thrombosis of, 101, 172-181; diagnosis from orbital cellulitis, 175-176; *post-mortem* examination of case of, 180.
Cellulitis, orbital, *see* Orbital Cellulitis.
Central artery, relation to optic nerve, 4.
Central vein of retina, 89.
Cerebellar tumour, 129.
Cerebellar veins, 92.
Cerebellum, effect of lesions, 23-24; disease of lateral lobe of, 26.
Cerebral arteries, 20-21.
Cerebral centres, localisation of, methods, 49.
Cerebral cortex, stimulation of, effect on ocular movements, 25-26.
Cerebral irritation, 137.
Cerebral peduncle, crusta of, 6.
Cerebral topography, 49-51.
Cerebral tumour, 105.
Cerebral veins, inferior, 92.
Cerebro-spinal fluid, increase of, 128.
Cervical nerve, second, 48.
Cervical lesion, paresis o left sympathetic nerve from, 144-148.
Check ligaments, 62, 75.
Cheek, innervation of skin of, 39; nerve supply to, 47, 48.
Chemosis, of ocular conjunctiva, 178.
Chiasma, 111, 112-115.
Choroid, 86, 89.
Choroid artery, anterior, 20, 21.
Choroid plexus, 128.
Ciliary arteries, 86, 87.
Ciliary bundle, 77, 78.
Ciliary ganglion, position of, 4; motor root, 31; sensory root, 37.

Ciliary muscle, nerve supply of, 28; motor fibres to, 31.
Ciliary nerves, 4, 12-13, 38.
Ciliary processes, 86, 88.
Ciliary veins, posterior, 89; anterior 89.
Cilio-retinal artery, 87.
Clot formation in intra-cranial sinuses, causes of, 173.
Collins, T., on congenital defects of lower lid, 104; case of suppuration in the orbit, 159,
Colman, Dr., *post-mortem* examination of case of septic thrombosis of cavernous sinus. 179-180.
Coloboma of lids, 104.
Columella of nose, 102.
Commissure of Gudden, function of fibres, 8.
Conjugate deviation, 24, 26.
Conjugate paralysis, 24-25.
Conjunctiva, innervation of, 40, 48; fornices of, 79, 83; development of, 104-105; œdema of, 171.
Conjunctiva, ocular, 164, 178.
Conjunctiva, palpebral, 76.
Cornea, 88, 171.
Corpora geniculata, blood supply of, 21.
Corpora quadrigemina, anterior, relation to afferent impulses of the visual tract, 9; connection with cortex, 11; effect of loss of eye on, 12; reflex centres in, 12; roots of optic tract in, 13; symptoms of lesions, 129
Corpora quadrigemina, blood supply of, 21; effect of lesions on vision, 23-24; sarcoma, 126-130; vascular lesions, 131-132.
Corpora quadrigemina inferior, function of, 12-13.
Corpus callosum, 15.
Corpus striatum, superficial covering of, 51.
Corrugator supercilii, 40.
Cortex cerebri, course of afferent visual fibres from basal nuclei, 13.
Cortical centres for vision, bullet wound of, 135-137; effect of lesions of, 139-140.
Coupland, Dr. Sidney, 181.
Cranial nerves (*see also* the different nerves), lengths of intradural parts, 34; affection of posterior, in cerebellar tumour, 129; paresis of, on the left side accompanying paresis of L. sympathetic nerve, 144-148.
Cribriform plate, 87.
Crises, visceral, 110.
Crista galli, 88.
Crura cerebri, blood supply of, 21.
Cuneal sulcus, 16.
Cuneus, the, 10, 14.
Cuneate lobe, effect of lesion of, 134, 140; bullet wound involving, 137; effect of indirect injury to, 141.
Cysts, retention, of Meibomian glands, 79.

DARKSCHEWITSCH and Mendel on the path of afferent impulses, 9.
Dental nerves, 98.
Dermoid cysts, 103, 105-106.
Dermoid of conjunctiva, 104.
Diaphragma sellæ, 91.
Diploe, 98.
Diplopia, 109, 130, 134, 145, 148, 157-158, 170.
Diplopia, homonymous, 121, 122, 127.
Diplopia, homonymous and crossed, methods of investigation, 57-60.
Diplopia, vertical, 120, 129, 131.
"Diseases of the Nose and Throat," *cited*, 161.
Disseminated sclerosis, 120-125.
Dorsum sellæ, 91.
Dura mater, 91; injury of, in operation on frontal sinus, 100.

EALES on cellulitis of orbit, 159.
Efferent fibres from visual cortex, 12, 13.
Emphysema of lids, 84-85, 100; of retro-ocular tissues, 100.
Empyema, frontal, 163; sphenoidal, 93; ethmoidal, 100, 158-162.
Encysted mucocele of orbit, 170-172.
Ependyma, 128.
Epileptic fits, history of, in case of orbita cellulitis, 165.
Episcleral arteries, 88.
Epistaxis, 168.
Ethmoid bone, uncinate process of, 98.
Ethmoidal arteries, 87-88.
Ethmoidal cells (anterior), 163-164.
Ethmoidal empyema, *see* Empyema.
Exenteration of orbit, 100.
Excision of the globe, 62.
Extra-ocular muscle, paresis of, from hæmorrhage into muscle sheath, 156-158.
Extra-ocular muscles, 30-31, 64-65.
Eye, displacement of, due to disease of nasal air cells, 159-160.
Eyelashes, 78.
Eyelids, innervation of skin of, 36, 37, 38; innervation of lower, 40, 48; blood supply of, 80-81; lymphatic vessels of, 82; development of lower, 104.

FACIAL nerve, distribution of, 48.
Facial paralysis, 124, 135.
False image, position of, in paresis of ocular muscles, 57-60.
Ferrier, *cited*, 10, 14, 15, 22, 132.
Fifth nerve—
  Area of, sensation over, in encysted mucocele of orbit, 170.
  Branches of, 36-37.
  Fourth nerve, communication with, 32.
  Ophthalmic division, *see* Ophthalmic Nerve,
  Second division, cutaneous distribution of. 48.
  Sixth nerve, communication with, 34.
  Superficial origin, 34.
  Superior maxillary division of, 38-39.
  Third division, distribution of motor branch, 48; cutaneous distribution of buccal branch, 47, 48.
  Third nerve, communication with, 29.
Fixation, muscles employed in, 54.
Flechsig, *cited*, 11, 14.
Foramina, jugular, 92; lacerum anterius, 87; lacerum medium, 177; magnum, 91; ovale, 177; rotundum, 91.
Fornices of conjunctiva, 79, 83.

Fourth nerve, nucleus of, 27; superficial origin, course and distribution, 31-32; length of intradural part, 34; relation with ophthalmic nerve, 35; relation with cavernous sinus, 90; paralysis of left, 148-152.
Fracture, of base of skull, 93; depressed, 133, 137, 140; compound, causing infective thrombosis, 173-174.
Frontal artery, 88.
Frontal bone, 95, 99.
Frontal convolutions, topographical position of, 50.
"Frontal line," 50.
Frontal lobes, removal of (monkey), 22.
Frontal nerve, 32, 36, 90.
Frontal sinus, 88, 163; operation on, 100.
Fronto-nasal plate, 102, 105, 106.
Frost, Adams, *cited*, 132.
Fuchs, E., *cited*, 71, 167.
Fundi in homonymous hemianopia, 142, 144.

GAIT of disseminated sclerosis, 124-125.
Ganglion habenulæ, 9.
Gasserian ganglion, 34, 38, 101.
Geniculate body, 6; effect of loss of eye on, 12.
Geniculate body, external, relation to visual fibres, 11; roots of optic tract in, 18.
Gennari, stripe of, 11, 17.
Girdle sensation, 110.
Glabella, 50, 84, 98, 100.
Glands—
  Meibomian, 79; retention cysts of, and treatment of, 79.
  Moll, of, 78.
Glaucoma, 43; chronic, 89-90.
Goître, parenchymatous, paralysis of L. sympathetic nerve from pressure of, 152-153.
Gowers, *cited*, 10, 109, 111, 132.
Gunn, D., on congenital distension of lacrimal sac, 103.
Gunn, Mr. Marcus, *cited*, 140, 143-144.

HALF vision centre, 13.
Haller, circle of, 87.
Hare, localisation of cerebral centres, method, 49.
Hartmann, on ethmoidal empyema, 161.
Head, on right sided hemianopia, 144.
Headache, 126, 142, 144-145, 156, 167.
Hearing, disturbances of, 116, 143.
Hemianopia, 13, 17, 134, 136, 141.
Hemianopia, bi-temporal, 112, 113, 114; homonymous, 134, 142-144.
Hemiopic pupillary phenomenon, 125, 127, 129, 133.
Hemiplegia, 135, 140.
Henschen, on occipital vision centres, 13-14, 139.
Hinshelwood, on the visual memory centre for letters and words, 19.
Holmes, on empyema of sphenoidal air-cell, 160.
Holmgren's test, 142.
Horner's muscle, 77-78, 84.
Horsley, method of localising cerebral centres, 49.
Hydatid cyst, orbital, 171.
Hypermetropia, 120, 139.
Hypoglossal nerve, paresis of left side with paresis of L. sympathetic nerve, 147.
Hypophysis cerebri, 91.

INFRA-ORBITAL groove, 97; foramen, 97; canal, 97.
Infra-orbital nerve, 97, 98; dental branches, 39-40.
Infra-trochlear nerve, 38, 47-48.
Infundibulum, the, 5, 98, 99, 164.
Intention tremor, 120.
Intercavernous sinuses, 91.
Internal jugular vein, 92, 176.
Interpeduncular space, 5.
Intracranial sinuses, clot formation in, causes of, 173.
Iris, 86, 88, 171.
Iritis, 88.

JACKSONIAN epilepsy, 22.
Jugular foramen, 92.

KILVERT, Mr., 174, 179.
Knapp, air cells of nose, disease of, on, 159; cases of orbital cellulitis recorded by, 159-160, 162; on empyema of ethmoidal cells, 100; operation through orbit, on cases of ethmoidal cell distension, 163.
Krönlein's operation, 100-101.

LACERATED foramen, anterior, 87.
Lacrimal bones, 83, 84, 95, 99, 103, 105.
Lacrimal fistula, 103.
Lacrimal gland, 82-83.
Lacrimal nerve, 32, 37, 87, 90.
Lacrimal papillæ, 80.
Lacrimal sac, 38, 48, 75, 83-84, 85.
Lambda, 135.
Lambdoid suture, 134.
Lamina cribrosa, 112, 125.
Landolt on excursion of ocular movements, 56.
Lang and Fitzgerald, on lesion of corpora quadrigemina, 132.
Langley, on dilator fibres of the pupil, 45.
Lateral sinus, 51, 92, 135.
Lawford, Mr., 167.
Lenticular ganglion, *see* Ciliary Ganglion.
Levator palpebræ superioris, 74, 83.
Lightning pains, 110.
Ligaments, of eyeball and eyelids, 62, 64, 75.
Limbus, 79-80.
Lip, sensory innervation of upper, 40.
Locomotor ataxy, 109, 114.
Long ciliary artery, 86.
Longitudinal fissure, 137.
Lymphatic glands, 82.
Lymphatic vessels of eyelid, 82.

MACEWEN'S "Pyogenic Diseases of the Brain and Cord," *cited*, 181.
Macula, 142.
Macular centre, blood supply of, 21.
Makins, Mr., 132, 137.
Malar bone, 96, 97, 101, 105, 106.
Marasmus, clot formation in intracranial sinuses, due to, 173.
Mastoid bone, 92.
Maxillary artery, internal, 97

Maxillary bone, superior, 83, 84; nasal process of, 95, 99, 102, 105; orbital surface, 96, 97; facial aspect, 97; palatal process, 103; development of, 103.
Maxillary plates, 103, 105, 106.
Maxillary, superior, division of fifth nerve, 91.
Meatus, superior, of nose, 99.
Meckel's ganglion, 39.
Mediastinal growth, 45.
*Medical Mirror*, *cited*, 158.
Medulla oblongata, blood supply of, 21.
Medullation of fibres, 3.
Memory centre, visual portion of, 18-19.
Meningeal branch of lacrimal artery, 87; middle m. vein, 91.
Meningitis, 102.
Mental nerve, cutaneous distribution, 48.
Meynert, *cited*, 8, 9.
Middle cerebral vein, 92.
Middle meningeal artery, 87.
Mole, congenital, *see* Dermoid.
Monakow, *cited*, 11, 16.
Motor cortex, topographical situation of, 50.
Mucocele, 84, 100; congenital, 103.
Mules' operation, 62.
Muscles:
  Co-ordination of 110.
  Expression, of, motor supply, 48.
  Inco-ordination of, 113, 122, 123-124, 126.
  Mastication, of, motor supply of, 48.
  Paresis of, 126-127.
  Rigidity of, 122.
Muscle-sheath, hæmorrhage into, 156-158.
Myosis, congestion, 88.

NARES, anterior, 102.
Nasal bones, development of, 103.
Nasal cavity, 103.
Nasal duct, 84; congenital atresia of, 84, 103.
Nasal nerve, 88, 90; relation to optic nerve, 4; course, distribution of, 37-38, 47, 48; orbital course, 48; eyeball, branches to, 46.
Nasal processes, lateral, 102; median, 102.
Nasal roof, 88.
Naso-facial sulcus, 103.
Nettleship, *cited*, 19, 112.
Neuritis, retro-bulbar, 115; optic, 126.
Neuro-paralytic keratitis with total left ophthalmoplegia, 148-152.
Neuro-retinitis, in total left ophthalmoplegia, 149.
Nictitating membrane, 80.
Nose (*see also* Nasal):
  Air cells of, disease of, 159-160.
  Blood supply of, 87.
  Examination of, in case of diffuse orbital cellulitis, 168.
  Innervation of, 38.
  Meatus of, inferior, 84.
  Meatus of, middle, 98, 99, 164.
  Sympathetic nerves of, 47, 48.
Nothnagel, *cited* on Lesion of corpora quadrigemina, 132.
Nuclei, *see* the Different Nerves.
Nystagmus, 26, 109, 110, 121, 122, 125, 126, 131.

OBLIQUE muscles—
  Antagonism of, 53.



Oblique Muscles—*continued.*
  Insertion of, 53; in myopic, hypermetropic, emmetropic eyeballs, 65.
  Movements produced by, 53, 55.
  Origin of, 65.
  Superior, 100.
Obstetrical paralysis of the trunk of the facial nerve, 40-41.
Occipital cortex—
  Anophthalmos, effect of, 17.
  Blindness, effect of, 17.
  Lesion of, localisation of, 134.
  Stimulation of, 23.
Occipital lobe—
  Arterial supply, 16.
  Histology of cortex, 16-17.
  Lesion of right, case of, 137.
  Limits of, 51.
  Localisation of visual centres in, 13-14.
  Loss of eye, effect of, 12.
  Visual memory, centre in, 18-19.
Occipital nerve, great, cutaneous distribution, 48.
Occipital nerve, small, origin, 48.
Occipital pole of the hemisphere, level of, 51.
Occipital protuberance, external, 50, 51, 134, 135.
Occipito-frontalis (muscle), innervation of belly of, 48.
Ocular movements—
  Centres for, 22.
  Convergence of optic axes, muscles employed in, 55.
  Extent of, 56.
  Limitation of, 115, 129.
  Muscles involved in, 67-68.
  Nerve supply involved in, 55, 68.
  Oblique muscles, 54.
  Recti muscles, 53.
  Restitution to primary position of parallelism, 55.
  Terms denoting, 52.
Ocular muscles—
  Angle of insertion, result of, 56, 70; in myopia and hypermetropia, 70.
  Balance of power between, 66-73.
  Paresis of, 125.
  Simultaneous action of, 54, 55, 66, 73.
  Tenon's capsule, importance of relation to, 61-62.
Oculo-motor nerve, external rectus muscle supplied by, 34.
Olfactory sense, 41.
Olivary eminence of the sphenoid bone, 5, 99.
Ophthalmic artery, relation to intracranial portion of optic nerve, 4; origin of, 19, 86; course of branches of, 86-88.
Ophthalmic nerve, 35, 90, 149.
Ophthalmic veins, 88-91, 92.
Ophthalmic vessels, 4.
Ophthalmoplegia, 22-23, 109-110, 113, 126, 130, 145; case of total left, 148-152.
Optic atrophy, 115, 124; primary, 109-111.
Optic chiasma, 4-5, 99.
Optic disc, nourishment of, 87; pallor of, 121, 125, 150; in total left ophthalmoplegia, 149; in encysted mucocele of orbit, 171.
Optic foramen, 4, 86, 89, 97, 99, 151.

Optic lobe, experimental irritation of, 24.
Optic nerve—
Course of, 3-4; fibres of, 6; decussation of, effect of loss of eye on, 12.
Lengths of orbital and intra-cranial portions, 4.
Relations of, 4, 30, 86, 87, 89.
Sheaths of, continuous with brain membranes, 4.
Optic papilla, 86.
Optic papillitis with total left ophthalmoplegia, 148-152.
Optic thalamus, 6, 20, 51.
Optic tracts, 4; course of, 5-6; roots, 6, 13; path of visual impulses in, 9-11; effect of loss of eye on, 12; visual fibres in, 13.
Orbicularis palpebrarum, 126; nerve supply 40, 78; origin and action, 76-77.
Orbit, 95-106; development, 102-106; suppuration in, 159.
Orbital canal, internal, anterior, 88; posterior, 87.
Orbital cavity, communication with nasal, 167, 169.
Orbital ellulitis, due to purulent ethmoiditis, 158-159; due to empyema, 160; diagnosis from septic thrombosis of cavernous sinus, 175-176.
Orbital margin, 106.
Orbito-nasal fissure, 102.
Ormerod, *cited*, on lesion of corpora quadrigemina, 132.
Os planum of ethmoid, 95, 99, 100.
Ossification centres of bones of orbit, 96.
Ostium ethmoidale, causes of occlusion of, 161.

PALATE, bone, 96; orbital process, 97, 99; vertical plate, 98.
Pallio-tectal fibres, 10.
Palpebral arteries, 87.
Palpebral fissure, 75, 116, 121.
Palpebral ligaments, 75.
Papillo-macular fasciculus, 6, 7.
Papillomata, 80.
Paralysis of nerves in cavernous sinus, 93.
Paresis, determination of the muscle at fault, 56.
Parotid gland, 82.
Parieto-occipital fissure, 51.
Patellar tendon reflex, 110, 113, 116, 121, 122, 123, 126, 127, 131, 142, 155.
Peduncle, cerebral, 5.
Perforating branches of anterior ciliary arteries, 88.
Perimetric fields, 113, 114, 118, 120, 123, 124, 134, 141, 142, 143, 144.
Periosteum of the orbit, 100.
Periostitis, 151; apical, 152; orbital, 158, 159.
Perspiration, partial, 146, 153.
Petro-occipital suture, 92.
Petrosal sinuses, 91, 92, 176.
Petro-squamous suture, 92.
Petrous bone, 92.
Pharyngeal venous plexus, 92, 177.
Philtrum of upper lip, 102.
Phosphorus necrosis, 161.
Pinna, 48, 82.
Pituitary body, 5, 91, 99.
Pituitary fossa, 113.
Plantar reflex, 123, 124.
Plica semilunaris, 38, 80.
Polypi, 161.
Pons varolii, blood supply of, 21.
Pontine tumour, case of, with conjugate paralysis, 25.
Porus opticus, 3.
Posterior longitudinal bundle, 28-29.
Premaxilla, 103.
Primary olfactory pits, 102.
Proptosis, 115, 120, 159, 164, 170, 171, 172, 178.
Pterygoid muscle, 48, 146.
Pterygoid venous plexus, 89, 92, 177.
Ptosis, 125, 126, 130, 145, 152, 154, 170.
Pulse, in lesion of corpora quadrigemina, 127; in orbital cellulitis, 167; in septic thrombosis of cavernous sinus, 179.
Pulvinar, course of visual fibres in, 11; effect of loss of eye, 12; roots of optic tract in, 13.
Puncta, congenital absence of, 84; congenital atresia of, 103.
Puncta lacrimalia, 80.
Punctured fracture of root of orbit, 102.
Pupillary fibres, course of, 9.
Pupillo-dilator fibres, communication with sympathetic system, 45.
Pupils—
Equality of, in lesion of cortical vision centre, 135; after depressed fracture, 139; in homonymous hemianopia, 142.
Inequality of, 110, 114, 121, 129, 131, 140, 153, 154.
Light reflex, 116, 117, 118, 121.
Reactions of, 124, 126, 127, 131, 133, 164.
Reflex on accommodation, 121.
Total left ophthalmoplegia, 148, 149.
Pyæmia, cellulitis of orbit due to infection from, 158.

RAMI communicantes from upper dorsal region, paralysis of R. sympathetic due to involvement of, 153-156.
Ramon-y-Cajal, on the course of visual fibres, 11-12; on reflex centres of corpora quadrigemina, 12.
Ramus of jaw, 82.
Recti muscles—
Antagonism of, 52.
External rectus muscle, innervation of, 34; paralysis of, 24-25; third nerve branches, 31.
Insertion of, 52, 65.
Movements produced by, 53, 55.
Optic nerve enclosed by, 4.
Origin of, 64.
Paresis of L. superior, 157,
Reflex contraction of the pupils, path of afferent impulses producing, 8-9.
Reid, 49.
Reil, Island of, 51.
Retina, blood supply of, 86; vascular disturbances of, 89; in total left ophthalmoplegia, 149.
Retinal association fibres, 8.
Retinitis, 117.

Retro-ocular abscess, perforation into ethmoidal cells and nose, 163.
Rhinitis, chronic hypertrophic, 161.
Riolanus, muscle of, 77.
Rolandic convolutions, left, bullet wound penetrating, 137.
Rolandic fissure, 50, 137, 140.
Rotation, limitation of term, 52.

*St. Thomas's Hospital Reports*, articles reprinted from, 158, 172-181.
Schäffer, case of orbital cellulitis, 160-161.
Schäfer on origin of visual fibres of the internal capsule, 10-11; on visual centres, 14; decussation of third nerve fibres, 28.
Schwalbe on Tenon's capsule, 63-64.
Sclera, 86.
Sclero-corneal junction, 80, 89.
Sclerotic, 89.
Scotoma, 112, 118; central, 121.
Sella turcica, 91, 99.
Sepsis, clot formation in intra-cranial sinuses from, 174.
Septic infection, possibility of spread of, by venous channels, 92-93.
Septum of nose, displacement of, in encysted mucocele of orbit, 171, 172.
Septum orbitale, 75.
Seventh nerve, nucleus of, 28; course of, 40-41; origin of fibres to orbicularis palpebrarum, 78.
Sharkey, on visual centres, 14; on lesion of corpora quadrigemina, 132.
Sherrington, on the centres for ocular movements, 22; on stimulation of the occipital cortex, 23.
Sixth nerve—
  Course and distribution, 33-34, 90.
  Intradural part, length of, 34.
  Nucleus of, 27.
  Orbital course of, 4.
  Paralysis of left, case of, 148-152.
  Relations of, 4, 30, 35, 90.
  Superficial origin, 32-33.
Skin, of face, nerve supply to, 48.
Skull, coronal section of, 51.
Smell, disturbances of, 116.
Snell, on lesion of corpora quadrigemina, 132.
Sonnenberg, case of ethmoidal distension, 162.
Speech, affections of, 120, 122, 124, 133.
Spheno-ethmoidal recess, 99.
Sphenoidal air sinuses, 91, 99, 159, 176.
Sphenoidal fissure, 89, 90, 91, 97, 151.
Sphenoid bone, body of, 5, 90, 95, 99; anterior clinoid process of, 86; orbital plate of, 97; great wing of, 96, 97, 101, 106; lesser wing of, 91, 96.
Spheno-maxillary fissure, 89, 91, 97, 101.
Sphincter pupillæ, nerve supply of, 28; motor fibres to, 31.
Spinal accessory nerve, 147.
Spinal myosis in tabes dorsalis, 111.
Spinal nerves, second and third, cutaneous distribution of anterior divisions, 48.
Spinal veins, anterior, 91.
Squamosal point, 50.
Stilling, on retinal association fibres, 8.
Stomodæum, 102.
Strabismus, 67, 69, 71, 72, 113.
Submaxillary lymphatic glands, 82.
Supra-marginal convolution, 50.
Supra-orbital artery, 87.
Supra-orbital margin, 95, 96.
Supra-orbital nerve, 36, 37, 149.
Supra-trochlear nerve, 36, 38, 88, paralysis of, in total left ophthalmoplegia, 149.
Suspensory ligament, 62.
Swanzy on hemianopic pupil, 129.
Sylvian fissure, 50, 51.
Sympathetic ganglion, superior, distribution of, 42.
Sympathetic nerve, communication with fourth nerve, 32; with sixth nerve, 34; paresis of left, from a cervical lesion, 144-148; paralysis of left, from pressure of goître, 152-153; paralysis of right, from involvement of rami communicantes, 153-156.

TABES dorsalis, *see* Locomotor Ataxy.
Tarsal ligaments, 62, 74-75, 84, 85.
Tarsal plate, 79.
Taylor, Dr. James, 113.
Tears, 83-84.
Temperature, 127, 178, 179, 180.
Temporal convolution, first, 144.
Temporal muscle, 48, 146.
Temporo-malar nerve, 37, 39.
Temporo-sphenodal lobe, bullet wound involving, 137i.
Tendon reflexes, 124.
Tenon's capsule, 79.
Tenotomy, 62, 69.
Tensor tarsi muscle, action of, 77-78.
Tentorium, 51, 92, 135.
Third nerve—
  Intra-dural part, length, 34.
  Nucleus of, 27-28, 78.
  Ophthalmic nerve, relation with, 35.
  Orbital cause of, 4.
  Paralysis of left, 148-152.
  Partial paralysis of, in paresis of L. sympathetic, 145.
  Relations, 4, 29-30, 90.
  Superficial origin, course and distribution, 29-31.
Thrombosis, septic, cavernous sinus, of, *see* Cavernous Sinus; infective, 173-174.
Tragus, 50, 82.
Tremor, muscular, 123, 127; intention, 124.
Trigonum habenulæ, 9, *and note.*
Tuber cinereum, 5.
Tumours of caruncle, 80.
Turbinate bone, inferior, 84; ethmoidal process, 98; sphenoidal process, 99.
Turck, on degenerative optic changes in tabes dorsalis, 111.
Turner, on path of fibres to visual centres, 14.
Turner, ablation of frontal lobes and angular gyri, 22.

VACCINATION, paresis of right sympathetic following re-vaccination, 153-156.
Valve of Hasner, 84.

Venæ vorticosæ, 89, 90.
Vermyne, case of ethmoidal distension recorded by, 162.
Vertebral artery, 44.
Vertigo, 120, 124, 125, 130, 142, 143, 145.
Vision, acuteness of, *see* Acuteness of Vision.
Vision, loss of, 138.
Visual centres, 10, 13, 21.
Visual fibres, path of, 10-11.
Visual impulses, path of, 9-11.
Visual memory centre, position of, 18-19.
Visual sensations, repeating subjective, in cortical affections, 143-144.
Visual sensory area, extent of 17-18.
Visual tracts, methods of investigation of, 6.
Vossius, 163.

WATSON, Spenser, 158.
Wernicke, on the course of the visual fibres, 10; on visual centres, 14.
Willis, circle of, 93.
Windle, on circle of Willis, 93.
Winking, afferent path of stimulus for, 48.
Word-blindness, 134, 144.
Word-deafness, 144.
Wormian-bone, 97.

ZINN, ligament of, 64.
Zygoma, 82.
Zygomatic fossa, 97.